REPORT OF THE PROCEEDINGS

OF THE

Forty-Eighth Annual Convention

OF THE

American Railway Master Mechanics' Association

(INCORPORATED)

HELD AT

ATLANTIC CITY, N. J.,

JUNE 9, 10 AND 11, 1915.

CHICAGO:
THE HENRY O. SHEPARD COMPANY
632 SHERMAN STREET
1915

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SUMMARY OF CONTENTS

REPORTS OF COMMITTEES AND DISCUSSIONS.

OFFICERS FOR 1915-16.

ELECTED AT THE CLOSE OF CONVENTION OF 1915.

PRESIDENT.

E. W. PRATT, A. S. M. P., C. & N. W. Ry., Chicago, Ill.

FIRST VICE-PRESIDENT.

WM. SCHLAFGE, G. M. S., Erie R. R., New York City.

SECOND VICE-PRESIDENT.

F. H. CLARK, G. S. M. P., B. & O. R. R., Baltimore, Md.

THIRD VICE-PRESIDENT.

W. J. TOLLERTON, G. M. S., C. R. I. & P. Ry., Chicago, Ill.

TREASURER.

ANGUS SINCLAIR, 114 Liberty street, New York City.

EXECUTIVE MEMBERS.

*JOHN PURCELL, Asst. to Pres., A. T. & S. F. Ry., Chicago, Ill.
*C. F. GILES, S. M., Louisville & Nashville R. R., Louisville, Ky.
*M. K. BARNUM, S. M. P., B. & O. R. R., Baltimore, Md.
†C. H. HOGAN, A. S. M. P., New York Central R. R., Albany, N. Y.
†J. F. DEVOY, A. S. M. P., C. M. & St. P. Ry., W. Milwaukee, Wis.
†J. T. WALLIS, G. S. M. P., Penna. R. R., Altoona, Pa.

SECRETARY.

JOS. W. TAYLOR, 1112 Karpen Building, Chicago, Ill.

†Term expires June, 1917.
*Term expires June, 1916.

LIST OF COMMITTEES SELECTED FOR THE 1916 CONVENTION

STANDING COMMITTEES.

1. Standards and Recommended Practice:

W. E. DUNHAM (Chairman), Supr. M. P. & M., C. & N. W. Ry., Winona, Minn.
B. B. MILNER, Engr. M. P., N. Y. Central Lines, New York City.
M. H. HAIG, M. E., A. T. & S. F. Ry., Topeka, Kan.
A. G. TRUMBULL, Asst. to G. M. S., Erie R. R., New York City.
C. D. YOUNG, Engr. Tests, Penna. R. R., Altoona, Pa.
G. S. GOODWIN, M. E., C. R. I. & P. Ry., Chicago, Ill.
R. L. ETTENGER, C. M. E., Southern Ry., Washington, D. C.

2. Mechanical Stokers:

A. KEARNEY (Chairman), A. S. M. P., N. & W. Ry., Roanoke, Va.
M. A. KINNEY, S. M. P., Hocking Valley R. R., Columbus, Ohio.
J. R. GOULD, S. M. P., C. & O. Ry., Richmond, Va.
J. T. CARROLL, A. G. S. M. P., Balto. & Ohio R. R., Baltimore, Md.
J. W. CYR, S. M. P., C. B. & Q. Ry., Chicago, Ill.
A. J. FRIES, A. S. M. P., N. Y. Central Lines, Depew, N. Y.
G. E. SISCO, A. E. M. P., Penna. Lines, Columbus, Ohio.

3. Fuel Economy and Smoke Prevention.

WM. SCHLAFGE (Chairman), G. M. S., Erie R. R., New York City.
W. H. FLYNN, S. M. P., Mich. Central R. R., Detroit, Mich.
D. M. PERINE, S. M. P., Penna. R. R., New York City.
ROBERT QUAYLE, G. S. M. P. & C., C. & N. W. Ry., Chicago, Ill.
F. H. CLARK, G. S. M. P., B. & O. R. R., Baltimore, Md.
D. J. REDDING, A. S. M. P., P. & L. E. R. R., McKee's Rocks, Pa.
W. J. TOLLERTON, G. M. S., C. R. I. & P. Ry., Chicago, Ill.

SPECIAL COMMITTEES.

4. Design and Maintenance of Locomotive Boilers:

C. E. FULLER (Chairman), S. M. P., Union Pacific R. R., Omaha, Neb.
A. W. GIBBS, C. M. E., Penna. R. R., Philadelphia, Pa.
D. R. MACBAIN, S. M. P., New York Central R. R., Cleveland, Ohio.
M. K. BARNUM, G. M. I., Balto. & Ohio R. R., Baltimore, Md.
R. E. SMITH, G. S. M. P., Atlantic Coast Line R. R., Wilmington, N. C.
C. B. YOUNG, M. E., Chgo., Bur. & Quincy R. R., Chicago, Ill.
J. SNOWDEN BELL, New York City.

5. Locomotive Headlights:

D. F. CRAWFORD (Chairman), G. S. M. P., Penna. Lines, Pittsburgh, Pa.
C. H. RAE, G. M. M., L. & N. R. R., Louisville, Ky.
F. A. TORREY, G. S. M. P., C. B. & Q. R. R., Chicago, Ill.
H. T. BENTLEY, S. M. P. & M., C. & N. W. Ry., Chicago, Ill.
M. K. BARNUM, S. M. P., Balto. & Ohio R. R., Baltimore, Md.
HENRY BARTLETT, G. M. S., B. & M. R. R., Boston, Mass.
W. H. FLYNN, S. M. P., Mich. Central R. R., Detroit, Mich.
W. O. MOODY, M. E., Illinois Central R. R., Chicago, Ill.

6. Superheater Locomotives:

W. J. TOLLERTON (Chairman), G. M. S., C. R. I. & P. Ry., Chicago, Ill.
H. W. CODDINGTON, Engr. Tests, N. & W. Ry., Roanoke, Va.
C. H. HOGAN, A. S. M. P., N. Y. C. & H. R. R. R., Albany, N. Y.
R. W. BELL, G. S. M. P., Ill. Cent. R. R., Chicago, Ill.
T. ROOPE, S. M. P., C. B. & Q. R. R., Lincoln, Neb.
W. C. A. HENRY, S. M. P., Penna. Lines, Columbus, Ohio.
E. W. PRATT, A. S. M. P., C. & N. W. Ry., Chicago, Ill.
G. M. BASFORD, 30 Church street, New York City.

7. Equalization of Long Locomotives:

WM. ELMER (Chairman), S. M. P., Penna. R. R., Buffalo, N. Y.
S. M. VAUCLAIN, Baldwin Locomotive Works, Philadelphia, Pa.
F. J. COLE, American Locomotive Works, Schenectady, N. Y.
O. C. CROMWELL, M. E., B. & O. R. R., Baltimore, Md.
J. F. ENRIGHT, S. M. P., D. & R. G. R. R., Denver, Colo.
C. H. RAE, G. M. M., L. & N. R. R., Louisville, Ky.
C. B. YOUNG, M. E., C. B. & Q. R. R., Chicago, Ill.

8. Dimensions of Flange and Screw Couplings for Injectors:

M. H. HAIG (Chairman), M. E., A. T. & S. F. Ry., Topeka, Kan.
T. F. BARTON, M. M., D. L. & W. R. R., Kingsland, N. J.
W. W. WINTERROWD, M. E., Can. Pac. Ry., Montreal.
B. F. KUHN, A. M. M., N. Y. C. R. R., Collinwood, Ohio.
S. B. ANDREWS, M. E., S. A. L. Ry., Portsmouth, Va.
M. D. FRANEY, M. M., N. Y. C. R. R., Elkhart, Ind.
J. C. MENGEL, M. M., Penna. R. R., Altoona, Pa.

9. Design, Maintenance and Operation of Electric Rolling Stock:

C. H. QUEREAU (Chairman), New York Central R. R., New York City.
G. C. BISHOP, S. M. P., Long Island R. R., Richmond Hill, L. I., New York City.
G. W. WILDIN, M. S., N. Y. N. H. & H. R. R., New Haven, Conn.
J. H. DAVIS, E. E., B. & O. R. R., Baltimore, Md.
R. D. HAWKINS, S. M. P., Great Northern Ry., St. Paul, Minn.
A. E. MANCHESTER, S. M. P., C. M. & St. P. Ry., W. Milwaukee, Wis.
T. W. HEINTZELMAN, G. S. M. P., Southern Pacific Co., San Francisco, Cal.

10. Best Design and Materials for Pistons, Valves, Rings and Bushings:

JOSEPH CHIDLEY (Chairman), A. S. M. P., N. Y. C. R. R., Cleveland, Ohio.
H. T. BENTLEY, S. M. P., C. & N. W. Ry., Chicago, Ill.
C. F. GILES, S. M., L. & N. R. R., Louisville, Ky.
A. K. GALLAWAY, M. M., B. & O. R. R., Baltimore, Md.
L. A. RICHARDSON, M. S., C. R. I. & P. Ry., Des Moines, Iowa.
G. W. RINK, M. E., C. R. R. of N. J., Jersey City, N. J.
W. D. ROBB, S. M. P., G. T. Ry., Montreal, Can.

11. Coöperation with Other Railway Mechanical Organizations:

JOHN PURCELL (Chairman), Asst. to Vice-Prest., A. T. & S. F. Ry., Chicago, Ill.
W. C. HAYES, S. L. O., Erie R. R., New York City.
F. C. PICKARD, M. M., D. L. & W. R. R., Buffalo, N. Y.
F. O. BUNNELL, Engr. Tests, C. R. I. & P. Ry., Chicago, Ill.
W. P. CARROLL, M. M., N. Y. C. R. R., Rochester, N. Y.
E. S. FITZSIMMONS, M. S., Erie R. R., New York City.
J. H. DAVIS, E. E., B. & O. R. R., Baltimore, Md.

12. Powdered Fuel:

C. H. HOGAN (Chairman), A. S. M. P., N. Y. C. R. R., Albany, N. Y.
E. W. PRATT, A. S. M. P., C. & N. W. Ry., Chicago, Ill.
THOS. ROOPE, S. M. P., C. B. & Q. R. R., Lincoln, Neb.
J. H. MANNING, S. M. P., D. & H. Co., Watervliet, N. Y.
CHARLES JAMES, M. S., Erie R. R., Cleveland, Ohio.
W. H. V. ROSING, S. E., St. L. & S. F. Ry., Springfield, Mo.
G. L. FOWLER, 83 Fulton street, New York City.

13. Specifications and Tests for Materials.

C. D. YOUNG (Chairman), Engr. Tests, Penna. R. R., Altoona, Pa.
J. R. ONDERDONK, Engr. Tests, B. & O. R. R., Baltimore, Md.
A. H. FETTERS, M. E., Union Pac. Ry., Omaha, Neb.
FRANK ZELENY, Engr. Tests, C. B. & Q. R. R., Chicago, Ill.
H. E. SMITH, Engr. Tests, N. Y. C. R. R., Collinwood, Ohio.
H. B. MACFARLAND, Engr. Tests, A. T. & S. F. Ry., Chicago, Ill.
PROF. L. S. RANDOLPH, Virginia Polytechnic Institute, Blacksburg, Va.

14. Train Resistance and Tonnage Rating:

P. F. SMITH, JR. (Chairman), S. M. P., Penna. Lines, Toledo, Ohio.
W. E. DUNHAM, Supt. M. P. & M., C. & N. W. Ry., Winona, Minn.
H. C. MANCHESTER, S. M. P., D. L. & W. R. R., Scranton, Pa.
C. E. CHAMBERS, S. M. P., C. R. R. of N. J., Jersey City, N. J.
J. H. MANNING, S. M. P., D. & H. Co., Watervliet, N Y.
FRANK ZELENY, Engr. Tests, C. B. & Q. R. R., Aurora, Ill.
L. B. JONES, A. E. M. P., Penna. Lines, Columbus, Ohio.
PROF. E. C. SCHMIDT, University of Illinois, Urbana, Ill.

15. Modernizing of Existing Locomotives:

F. J. COLE (Chairman), American Loco. Co., Schenectady, N. Y.
J. C. LITTLE, M. E., C. & N. W. Ry., Chicago, Ill.
C. A. GILL, G. M. M., B. & O. R. R., Baltimore, Md.
M. J. DRURY, S. S., A. T. & S. F. Ry., Topeka, Kan.
R. D. HAWKINS, S. M. P., G. N. Ry., St. Paul, Minn.
D. J. MULLEN, S. M. P., C. C. C. & St. L. Ry., Indianapolis, Ind.
J. SNOWDEN BELL, New York City.

16. Subjects:

A. W. GIBBS, C. M. E., Penna. R. R., Philadelphia, Pa.
D. R. MacBAIN, S. M. P., L. S. & M. S. Ry., Cleveland, Ohio.
C. E. FULLER, S. M. P., Union Pacific R. R., Omaha, Neb.

17. Arrangements:

E. W. PRATT, A. S. M. P., C. & N. W. Ry., Chicago, Ill.
D. R. MacBAIN, S. M. P., N. Y. C. R. R., Cleveland, Ohio.
O. F. OSTBY, 80 Broadway, New York City.

CONSTITUTION AND BY-LAWS.

ARTICLE I.

NAME.

The name of this Association shall be the "American Railway Master Mechanics' Association."

ARTICLE II.

OBJECTS OF ASSOCIATION.

The objects of this Association shall be the advancement of knowledge concerning the principles, construction, repair and service of the rolling stock of railroads, by discussions in common, the exchange of information, and investigations and reports of the experience of its members; and to provide an organization through which the members may agree upon such joint action as may be required to give the greatest efficiency to the equipment of railroads which is intrusted to their care.

Subjects involving legal, transportation, permanent way or traffic questions, or for any other reason requiring such action, may be submitted as recommendations to the American Railway Association.

ARTICLE III.

MEMBERSHIP.

SECTION 1. The following persons may become active members of the Association on being recommended by two members in good standing, signing an application for membership and agreement to conform to the requirements of the Constitution and By-Laws, or authorizing the Secretary to sign the Constitution for them:

(1) Those above the rank of general foreman, having charge of the design, construction or repair of railway rolling stock.

(2) General foremen, if their names are presented by their superior officers.

(3) Two representatives from each locomotive and car building works.

(4) One representative member may be appointed by any railroad company to represent its interests in the Association. Such appointment shall be in writing and shall emanate from the President, General Manager or General Superintendent. Such member shall have all the privileges of an active member, including one vote on all questions, and, in addition thereto, shall, on all measures pertaining to the determination of what tests shall be conducted by the Association or the expenditure of money for conducting same, have one additional vote for each full one hundred

engines which are in actual operation or in process of purchase by the road or system which he represents. Such membership shall continue until notice is given the Association of his withdrawal or the appointment of his successor.

SEC. 2. Civil and mechanical engineers, or other persons having such a knowledge of science or practical experience in matters pertaining to the construction of rolling stock as would be of special value to the Association or railroad companies, may become associate members on being recommended by three active members. The name of such candidate shall then be referred to a committee, to be appointed by the President, which shall investigate the fitness of the candidate, and report to the Executive Committee of the Association at the next annual meeting. If the report be unanimous in favor of the candidate the name shall be submitted to letter ballot, and five dissenting votes shall reject. The number of associate members shall not exceed twenty, and they shall be entitled to all the privileges of active members, excepting that of voting.

SEC. 3. (1) All active and associate members of the Association, excepting as hereafter provided, shall be subject to the payment of such annual dues as it may be necessary to assess for the purpose of defraying the expenses of the Association, provided that no assessment shall exceed $5 a year.

(2) A representative member shall pay in addition to his personal dues as above, an amount for each additional vote to which he is entitled, as shall be determined each year by the Executive Committee, prorated upon the cost of conducting such tests as may be determined upon at each convention.

Such dues shall be payable when the amount thereof is announced by the President, at each annual meeting. Any member who shall be two years in arrears for annual dues, shall be notified of the fact, and if the arrears are not paid within three months after such notification, his name shall be taken from the roll and he be duly notified of the same by the Secretary.

SEC. 4. Any person who has been or may be duly qualified as a member of this Association will remain such until his resignation is voluntarily tendered, or he becomes disqualified by the terms of the Constitution. Members whose names have been dropped for non-payment of dues may be restored to membership by the unanimous consent of the Executive Committee on the payment of all back dues.

SEC. 5. Members of the Association, active or associate, who have been in good standing for not less than twenty years, and who through age or other cause cease to be actively engaged in the mechanical department of railway service, may, upon the unanimous vote of the members present at the annual meeting, be elected honorary members. The nominations must be made by the Executive Committee. The dues of the honorary members shall be remitted, and they shall have all the privileges of active members except that of voting.

SEC. 6. Any member who, during the meetings of the Association,

shall be guilty of dishonorable conduct which is disgraceful to a railroad officer and member of the Association, or shall refuse to obey the chairman when called to order, may be expelled by a two-thirds affirmative vote at any regular meeting of the Association held within one year from the date of the offense.

ARTICLE IV.

OFFICERS.

SECTION 1. The officers of the Association shall be a President, a First Vice-President, a Second Vice-President, a Third Vice-President, a Treasurer, a Secretary, and six Executive members, the six Executive members with the President, Vice-Presidents and Treasurer shall constitute the Executive Committee, and they, with the exception of the Secretary, shall constitute the Executive Committee of the Association.

ARTICLE V.

DUTIES OF OFFICERS.

SECTION 1. It shall be the duty of the President to preside at all the meetings of the Association, appoint all committees — designating the chairman — except as hereinafter provided, and approve all bills against the Association for payment by the Treasurer.

SEC. 2. It shall be the duty of the Vice-Presidents, according to rank, to perform the duties of the President in his absence from the meetings of the Association.

SEC. 3. In case of the absence of both President and Vice-Presidents, the members present shall elect a President *pro tempore.*

SEC. 4. It shall be the duty of the Secretary to keep a full and correct record of all transactions at the meetings of the Association; to keep a record of the names and places of residence of all members, and the name of the railway they each represent; to certify to the persons who are eligible as candidates for the Association's scholarships at the Stevens Institute of Technology; to receive and keep an account of all money paid to the Association and deliver the same to the Treasurer, taking his receipt for the amount; to receive from the Treasurer all paid bills, giving him a receipted statement of the same.

SEC. 5. It shall be the duty of the Treasurer to receive all money from the Secretary belonging to the Association; to receive all bills and pay the same, after having approval of the President; to deliver all bills paid to the Secretary at the close of each meeting, taking a receipted statement of the same and to keep an accurate book account of all transactions pertaining to his office.

ARTICLE VI.

EXECUTIVE COMMITTEE.

SECTION 1. The Executive Committee shall exercise a general supervision over the interests and affairs of the Association, recommend the

amount of the annual assessment, to call, to prepare for, and to conduct general conventions, and to make all necessary purchases, expenditures and contracts required to conduct the current business of the Association, but shall have no power to make the Association liable for any debt to an amount beyond that which at the time of contracting the same shall be in the Treasurer's hands in cash, but not subject to prior liabilities. All expenditures for special purposes shall only be made by appropriations acted upon by the Association at a regular meeting.

SEC. 2. The Executive Committee shall receive, examine and approve before public reading, all communications, papers and reports on all mechanical and scientific matters; they shall decide what portion of the reports, papers and drawings shall be submitted to each convention and what portion shall be printed in the annual report. It shall also determine which, if any, of the subjects presented at the convention, or by the members, shall be referred to the American Railway Association.

SEC. 3. Five members of the Executive Committee shall constitute a quorum for the transaction of business.

SEC. 4. The Executive Committee shall form with a committee of the Master Car Builders' Association a Joint Committee to decide on the place of meeting for the annual convention.

ARTICLE VII.

ASSOCIATION SCHOLARSHIPS.

It shall be the duty of the Secretary to issue a circular annually, intimating the date and place when and where candidates may be examined for the scholarships of the Association in the Stevens Institute of Technology, Hoboken, New Jersey.

Acceptable candidates for the scholarship shall be, first, sons of members or of deceased members of the Association. If there is not a sufficient number of such applicants for the June examination, then applications will be received from other railroad employes or the sons of other railroad employes for the fall examination. The Secretary shall issue a proper circular in this case as before. In extending the privilege outside of the families of members, preference shall be given to employes or the sons of employes, or the sons of deceased employes of the mechanical departments.

Candidates for these scholarships shall apply to the Secretary of this Association, and if found eligible shall be given a certificate to that effect for presentation to the school authorities. This will entitle the candidate to attend the preliminary examination. If more than one candidate passes the preliminary examination, the applicant passing the highest examination shall be entitled to the scholarship, the school authorities settling the question.

The successful candidate shall be required to take the course of mechanical engineering.

ARTICLE VIII.

ELECTION OF OFFICERS.

SECTION 1. The officers of the Association, except the Secretary as hereinafter provided, shall be elected by ballot separately without nomination at the regular meeting of the Association, held in June of each year. A majority of all votes cast shall be necessary to an election, and elections shall not be postponed. The President, Vice-Presidents and Treasurer shall hold office for one year, and Executive members for two years, or until successors are chosen, provided, however, that three Executive members shall be elected for one year at the time of the adoption of this amendment. Three Executive members shall be elected each year thereafter.

SEC. 2. Two tellers shall be appointed by the President to conduct the election and report the results.

SEC. 3. A Secretary from among the members of the Association shall be appointed by a majority of the Executive Committee at its first meeting after the annual election, or as soon thereafter as the votes of a majority of the members of the Executive Committee can be secured for a candidate. The term of office of the Secretary thus appointed, unless terminated sooner, shall cease at the first meeting, after the next annual election succeeding his appointment, of the Executive Committee organized for the transaction of business. Two-thirds of the members of the Executive Committee shall have power to remove the Secretary at any time. His compensation, if any, shall be fixed for the time that he holds office by vote of the majority of the Executive Committee. He shall also act as Secretary of the Executive Committee.

ARTICLE IX.

AUDITING COMMITTEE.

SECTION 1. At the first session of the annual meeting an Auditing Committee, consisting of three members not officers of the Association, to be nominated by any member who does not hold office, shall be elected in the same way as officers are voted for. This Auditing Committee shall examine the accounts and vouchers of the Treasurer and certify whether they have been found correct or not. After the performance of this duty they shall be discharged by the acceptance of their report by the Association.

COMMITTEE ON SUBJECTS FOR INVESTIGATION AND DISCUSSION.

SEC. 2. At each annual meeting the President shall appoint a commitee whose duty it shall be to report at the next annual meeting subjects for investigation and discussion, and if the subjects are approved by the Association the President, as hereinafter provided, shall appoint committees to report on them. It shall also be the duty of the committee to receive from members questions for discussion during the time set apart for that purpose. This committee shall determine whether such questions are

suitable ones for discussion, and if so, they shall so report them to the Association.

COMMITTEES ON INVESTIGATION.

SEC. 3. When the Committee on Subjects has reported, and the Association approved of subjects for investigation, the President shall appoint individuals or special committees to investigate and report on them, and may authorize and appoint a *special* committee to investigate and report on any subject which a majority of the members present may approve; or individual papers may be presented to the Association after approval by the Executive Committee. Papers and reports shall be presented by abstracts, which shall not occupy more than ten minutes in the reading unless otherwise ordered by the Association.

RECOMMENDATIONS OF STANDARDS.

SEC. 4. Any proposition recommending the adoption of standard construction or practice shall be in writing and be accompanied by drawings, if the latter are necessary for a clear understanding of the subject. Such proposition shall then be submitted to the Association for discussion, after which a vote shall be taken to decide whether the proposition shall be submitted for decision by letter ballot to all the members entitled to vote. If decided in the affirmative, the Secretary, within three months from the time the vote of the Association is taken on such measure, shall send by mail to each member a blank ballot, and a copy of the proposed recommendation, with a report, to be approved by the Executive Committee, of the discussion thereon; such ballot to be filled up, signed and remailed to the Secretary, who will count all the ballots received within thirty days from the date they were sent to the members, and he shall then announce the vote in such manner as the Executive Committee may prescribe. Any recommendation securing two-thirds of the votes cast shall be adopted by the Association.

SEC. 5. All reports, resolutions and recommendations involving the use, or proposed use, by railroad companies, of any device or process which forms the subject matter of any existing patent, shall first be submitted to the Executive Committee, and shall be submitted to the Association only by the Executive Committee.

ARTICLE X.

AMENDMENTS.

SECTION 1. The Constitution may be amended at any regular meeting by a two-thirds vote of the members present, provided that written notice of the proposed amendments has been given at a previous meeting at least six months before.

BY-LAWS

TIME OF MEETING.

I. The regular meeting of the Association shall be held annually in June of each year.

HOURS OF SESSION.

II. The regular hours of session shall be from 9:30 o'clock A.M. to 1:30 o'clock P.M.

PLACE OF MEETING.

III. The time and place for holding the Annual Convention shall be selected by a Joint Committee composed of the President, three Vice-Presidents and Treasurer of this Association and a corresponding committee from the Master Car Builders' Association. This Joint Committee shall meet within six months after the convention and decide upon the time and place of meeting.

QUORUM.

IV. At any regular meeting of the Association, fifteen or more members entitled to vote shall constitute a quorum.

ORDER OF BUSINESS.

V. The business of the meetings of this Association shall, unless otherwise ordered by a vote, proceed in the following order:

1. Opening prayer.
2. Address by the President.
3. Acting on the minutes of the last meeting.
4. Reports of Secretary and Treasurer.
5. Assessment and announcement of annual dues.
6. Election of Auditing Committee.
7. Unfinished business.
8. New business.
9. Reports of committees.
10. Reading of papers and discussion of questions propounded by members.

11. Routine and miscellaneous business.

12. Election of officers.

13. Adjournment.

QUESTIONS FOR DISCUSSION, SPECIAL ORDER OF.

VI. Unless otherwise ordered, the discussion of questions proposed by members shall be the special order from 12 o'clock M. to 1 P.M. of each day of the annual meeting.

DECISIONS.

VII. The votes of a majority of the members shall be required to decide any question, motion or resolution which shall come before the Association, unless otherwise provided.

DISCUSSIONS.

VIII. No patentees or their agents shall be admitted in the meetings of the Association for the purpose of advocating the claims of any patent or patentee, unless by unanimous consent.

IX. No member shall speak more than twice in the discussion of any question until all the other members who want to speak, and have not been heard, have spoken, and no member shall have the floor more than five minutes at a time unless otherwise ordered.

X. The reports of all standing and special committees must be in the office of the Secretary not later than April 1, in order that the same can be printed and advance copies issued by May 1.

XI. Committee reports which do not reach the Secretary in time for printing and issuing by May 1 will be referred to the Executive Committee to decide whether the report shall be submitted to the convention.

XII. The chairman of a standing or special committee will read an abstract of the report of the committee before the convention, together with whatever additional data may have been accumulated after April 1, to the date of the convention.

XIII. The members of standing and special committees who may individually or collectively submit a minority report, must prepare the same so that it can be issued with the report of the majority of the committee and substituted for the majority report in the event the convention should so decide.

XVI. Each member of a standing or special committee must sign either the majority or the minority report.

NAMES AND ADDRESSES OF MEMBERS.

Active members are shown in Roman letters; representative members in Italics.

ACTIVE MEMBERS.

JOINED.	NAME.	NO. OF LOCOS.	ROAD.	ADDRESS.
1912	Abbott, A. S		M. S., St. L. & S. F. R. R	Springfield, Mo.
1903	Adams, A. C		Gen. Brake Shoe & Supply Co	Portland, Ore.
1914	Airhart, N. S		M. M., M. K. & T. Ry	Denison, Tex.
1907	Akans, Geo		M. M., Southern Ry	Atlanta, Ga.
1914	Akans, E. L		M. M., V. & S. W. Ry	Bristol, Va.-Tenn.
1887	Aldcorn, Thos		Chicago Pneumatic Tool Co	95 Liberty st., N. Y. City
1913	Alexander, W		R. R. Com. of Wis	Madison, Wis.
1909	Allan, Arthur		S. M., The Holden Co	Montreal, Can.
1906	Allen, C. W			Reading, Pa.
1911	Alling, Edward W		M. M., N. Y. N. H. & H. R. R	New Haven, Conn.
1908	Allison, W. L		W. S. M., Franklin Ry. Supply Co	Chicago, Ill.
1907	Allport, J. S		M. M., B. C. G. & A. R. R	Boyne City, Mich.
1914	Anderson, J. A		M. M., Balto. & Ohio R. R	Lorain, Ohio.
1913	Andrus, C. H		M. M., Penna. R. R	Harrisburg, Pa.
1909	Anthony, F. S			Marshall, Tex.
1906	Appler, A. B		M. E., Dela. & Hudson Co	Watervliet, N. Y.
1914	Appleton, W. U		G. M. M., Can. Government Rys	Moncton, N. B.
1911	Arden, D. D		M. M., Savannah & Statesboro Ry	Statesboro, Ga.
1887	Arp, W. C		S. M. P., Vandalia R. R	Terre Haute, Ind.
1914	Arroyo, E		M. M., Nor. Cent. Ry. of Argentine	Tucuman, Arg. Rep.
1914	Arter, W. D		Supt. Appr., N. Y. C. & H. R. R. R	New York City.
1903	Ashton, Harry			309 Delaware ave., Toronto, Ont.
1890	Atkinson, R			633 No. 17th st, Philadelphia, Pa.
1896	Atterbury, W. W		V.-P., Penna. R. R	Philadelphia, Pa.
1886	Austin, W. L		Baldwin Locomotive Works	Philadelphia, Pa.
1907	Ayers, A. R		P. A. E., N. Y. Cent. R. R	New York City.
1903	Ayers, H. B		Care H. K. Porter Co	Pittsburgh, Pa.
1912	Babcock, W. G		M. M., N. Y. C. R. R	Harmon, N. Y.
1893	Baker, G. H			227 Monroe st., New York City.
1902	Baker, P. G			4947 Chestnut st., Philadelphia, Pa
1905	Balderston, J. W			340 So. State st., Los Angeles, Cal
1901	Ball, H. F		Economy Devices Corp	30 Church st., New York City.
1912	Band, R. W		S. S., Boston & Maine R. R	Keene, N. H.
1910	Bannatyne, A. W		C. M. E., Buenos Aires Western Ry	Liniers, Buenos Aires, Arg. Rep., S. A.
1905	Barclay, F. B		S. M. P., Illinois Central R. R	Memphis, Tenn.
1915	Barnhill, C. F		M. M., G. C. & S. F. Ry	Silsbee, Tex.

JOINED.	NAME.	NO. OF LOCOS.	ROAD.	ADDRESS.
1890	Barnum, M. K		S. M. P., Baltimore & Ohio R. R	Baltimore, Md.
1913	Baroni, Jos			
1895	Bartlett, Henry		G. S. M. P., Boston & Maine R. R	Boston, Mass.
1912	Barrett, C. D		A. E. M. P., Penna. R. R	Williamsport, Pa.
1915	Barry, F. J		M.M., N. Y. O. & W. Ry	Childs, Pa.
1904	Barton, T. F		M. M., D. L. & W. R. R	Kingsland, N. J.
1914	Baumgardner, F. M		M. M., Ill. Cent. R. R	Clinton, Ill.
1909	Bawden, Wm		M. M., Terminal R. R. Assn. of St. Louis	St. Louis, Mo.
1909	Bayley, J. J		M. M., Southern Ry	Lawrenceville, Va.
1908	Beamer, Jas. A		M. M., Penna. R. R	Tyrone, Pa.
1892	Beattie, A. L		S. M. P., New Zealand Government Rys.	Wellington, N. Z.
1889	Bean, S. L		M. S., A. T. & S. F. Ry	Los Angeles, Cal.
1894	Beaumont, J. G		Southern Rys. of Peru	Arequipa, Peru, S. A.
1912	Becker, E		M. M., C. & N. W. Ry	Escanaba, Mich.
1911	Bedell, W. A		M. M., Missouri Pacific Ry	Jefferson City, Mo.
1915	Bell, R. E		D. M. M., G. C. & S. F. Ry	Galveston, Tex.
1910	*Bell, R. W*	1667	*G. S. M. P., I. C. R. R*	*Park Row, Chicago, Ill.*
1910	Bennett, W. H		M. M., Pennsylvania R. R	Juniata, Pa.
1903	Bennett, W. J		M. M., Denver & Rio Grande R. R	Salt Lake City, Utah.
1900	Bentley, H. T		A. S. M. P., C. & N. W. Ry	Chicago, Ill.
1906	Bentley, L. L		Armstrong Cork Co	Beaver Falls, Pa.
1902	Berry, Arthur O		S. M. E., Div. of Val.-I. C. C	Chattanooga, Tenn.
1900	Best, W. N		W. N. Best International Calorific Co.	New York, N. Y.
1912	Beyer, O. S., Jr		G. F., Rock Island Lines	Horton, Kan.
1913	Bickford, S. A		M. M., N. Y. C. R. R	New York City.
1903	Billingham, R. A		M. M., Apalachicola Nor. R. R	Port St. Joe, Fla.
1902	Bingaman, C. A		A. E. M. P., Phila. & Reading R. R	Reading, Pa.
1911	Bingley, W. J		M. M., Western Maryland Ry	Hagerstown, Md.
1910	*Bishop, G. C*	182	*S. M. P., Long Island R. R*	*Richmond Hill, N. Y.*
1899	Bissett, J. R		M. M., Seaboard Air Line Ry	Raleigh, N. C.
1909	Black, W. G		M. M., N. Y. C. & St. L. R. R	Stony Island, Chicago, Ill.
1901	Blake, R. P			941 4th ave., So. Fargo, N. D
1909	Blunt, James G		Supt. Gen. Drawing Room, Amer. Loco. Co	Schenectady, N. Y.
1904	*Bock, M. G*	6	*S. M. P. & R. S., DeQueen & Eastern R. R*	*DeQueen, Ark.*
1910	Booth, J. K		Genl. Foreman, Bessemer & Lake Erie R. R	Greenville, Pa.
1913	Borcea, Ed		M. E., Roumanian Govt. Rys	Bucharest, Roumania.
1911	Bornefeld, G. C		Calle 25 de Mayo 158	Buenos Aires, Arg. Rep.
1914	Bosworth, W. M		M. E., L. & N. R. R	Louisville, Ky.
1909	Boughton, Wm			426 W. Grand blvd., Detroit, Mich.
1915	Boulineau, W. W		M. M., Central of Georgia R. R	Cadartown, Ga.
1914	Bowersox, C		M. M., Tol. & Ohio Cent. R. R	Bucyrus, Ohio.
1897	Bowles, C. K		Tidewater & Western R. R. Co	Chester, Va.
1907	Boyden, J. A		M. M., Erie R. R	Cleveland, Ohio.
1914	Boyden, N. N		M. M., Southern Ry	Knoxville, Tenn.
1915	Brand, A		Lake Terminal Railroad	Lorain, Ohio.
1911	Brandt, C. A		A. M. M., C. C. C. & St. L. Ry	Indianapolis, Ind.
1896	Brangs, P. H			11 Broadway, New York City.
1900	*Brassell, James K*	66	*M. M., California & Northwestern Ry*	Tiburon, Cal.
1902	Brasier, F. W		S. R. S., N. Y. C. R. R	New York City.
1892	Brehm, W. H		M. M., M. K. & T. Ry	Parsons, Kan.
1904	Breneman, H. N			135 N. Duke st., Lancaster, Pa.
1913	Brennan, E. J		M. M., B. R. & P. Ry	Du Bois, Pa.
1911	Brewer, J. W		Chicago & Alton R. R	3503 So. California ave., Chicago, Ill.

JOINED.	NAME.	NO. OF LOCOS.	ROAD.	ADDRESS.
1914	Breyer, J. S.		M. M., Southern Ry	Charleston, S. C.
1909	Bridges, E. A		Durham & Southern Ry	Durham, N. C.
1913	Brogden, J. E		G. F., A. C. L. R. R	Montgomery, Ala.
1887	Brooke, G. D			2742 Bryant ave., Minneapolis, Minn.
1911	Brown, H. M		S. S., Chesapeake & Ohio Ry	Huntington, W. Va.
1900	*Brown, M. G*	49	*S. M. P., Gulf & Ship Island R. R*	*Gulfport, Miss.*
1904	Brown, T. A		S. M. P., Louisiana & Ark. Ry	Stamps, Ark.
1897	Bruce, G. A		G. M. M., Gt. Nor. Ry. Line	St. Paul, Minn.
1890	Bruck, H. T			
1900	Buchanan, A., Jr			2517 Grand Central Terminal, New York.
1911	Bunker, W. D		M. M., Colorado & Wyoming Ry	Pueblo, Colo.
1906	Burel, W. C		Gen. Fore., L. & C. Dept., Ore. Short Line Ry	Salt Lake City.
1905	Burgis, E. W		G. S., N. O. S. & G. I. Ry	New Orleans, La.
1909	Burk, C. H		Loco. Supt., Mexican Ry	Orizaba, V. C., Mex.
1910	Burley, J. M	97	Oregon-Washington R. R	LeGrande, Ore.
1912	Burns, Jno		M. M., Canadian Pacific Ry	Montreal, Can.
1913	Burns, T. J		S. R. S., Mich. Cent. R. R	Detroit, Mich.
1909	Burton, T. L			1932 No. Broadway, St. Louis, Mo.
1893	Bush, S. P		G. M., Buckeye Steel Castings Co	Columbus, Ohio.
1903	Bushmeyer, C. J			
1906	Bussing, G. H		S. M. P., Mexico No. Western Ry	Madera, Chih., Mexico.
1913	Butler, F. A		M. M., B. & A. R. R	Bracon Park, Allston, Mass.
1911	Butler, W. S		M. M., Chesapeake & Ohio Ry	Huntington, W. Va.
1914	Byers, R. F			1636 No. 61st st., Philadelphia, Pa
1912	Byron, A. W		M. M., Penna. R. R	South Pittsburgh Shops, Pittsburgh, Pa.
1903	Campbell, A. A			2223 Laurel st., Shreveport, La.
1914	Campbell, W. M		Dearborn Chemical Co	Reconquista 46 Buenos Aires, Arg. Rep.
1909	Canfield, J. B		M. M., Boston & Albany R. R	West Springfield, Mass.
1902	Caracristi, V. Z			30 Church st., New York City.
1913	Carey, J. J		M. M., Tex. & Pac. Ry	Marshall, Tex.
1900	Carney, J. A		Supt. Shops, C. B. & Q. R. R	Aurora, Ill.
1907	Carroll, John T		A. S. M. P., B. & O. R. R	Baltimore, Md.
1911	Carroll, W. P		M. M., New York Central Lines	Rochester, N. Y.
1907	Carson, H. M		Gen. Supt., Penna. R. R. (Erie Div.)	Williamsport, Pa.
1915	*Carson, F. L*	93	*A. S. M. P., S. A. & A. P. Ry*	*Yoakum, Tex.*
1914	Cassady, J. A		M. M., Ala. Gt. So. R. R	Birmingham, Ala.
1904	Cassidy, D. E		Asst. M. M., W. P. Div., Penna. R. R. Co	Verona, Pa.
1912	Chadwick, G. H		Loco. Supt., Cent. Ry. of Peru	Lima, Peru, S. A.
1892	Chamberlin, E			2621 Grand Central Depot, New York, N. Y.
1914	Chamberlin, S. A			914 Karpen Bldg., Chicago, Ill.
1892	Chambers, C. E		S. M. P., C. R. R. of N. J	Jersey City, N. J.
1909	Chenowith, Edwin G		M. E., C. R. I. & P. Ry	Chicago, Ill.
1905	Chidley, Joseph		A. S. M. P., N. Y. C. R. R	Cleveland, Ohio.
1906	Chisholm, J. E		Railway Supplies	Chicago, Ill.
1902	Churchward, G. J		L. C. & W. Supt., Great Western Ry	Swindon, Eng.
1899	Clark, F. H		G. S. M. P., B. & O. R. R	Baltimore, Md.
1903	Clark, J. H		M. M., Staten Island Rapid Transit Ry. Co	Clinton, S. I., N. Y.
1897	Clarke, Owen		M. M., Texas & Pacific Ry. Co	Marshall, Tex.

JOINED.	NAME.	NO. OF LOCOS.	ROAD.	ADDRESS.
1914	Clark, P. J.			
1903	Clarkson, Wm. S.			708 Orange st., New Haven, Conn.
1910	Cleland, M. E.		Div. Foreman, Philippine Ry.	Cebu, Island of Cebu, P. I.
1893	Clever, F. C.			Rutland, Vt.
1915	Clewer, H.		S. L. O., Rock Island Lines	Chicago, Ill.
1884	Clifford, J. G.		M. M., L. & N. R. R.	Louisville, Ky.
1887	Cloud, Jno. W.			82 York Road, King's Cross, London, Eng.
1903	Cockfield, Wm.		Argentine Ry.	Buenos Aires, Agr. Rep., S. A.
1915	Cockrane, R. J.		A. W. M., Central Cordoba Ry.	Cordoba, Arg. Rep., S. A.
1913	Coddington, H. W.		Engr. Tests, N. & W. R. R.	Roanoke, Va.
1896	Cole, F. J.		C. C. E., American Locomotive Co.	Schenectady, N. Y.
1911	Cole, Jos.		M. S., Vera Cruz Terminal Co.	Vera Cruz, V. C., Mex.
1914	Cole, H. L.		Asst. Secy., Indian Govt. Ry. Board	Simla, Pumjab, India.
1904	Cole, Thos. J.		M. M., Erie R. R. Co.	Meadville, Pa.
1909	Coleman, C.		M. M. (Nor. Iowa & Sioux City Div.), Chicago & North Western Ry.	Winona, Minn.
1907	Collier, L. L.		M. M., P. & I. N. Ry.	New Meadows, Idaho.
1906	Collins, W. H.		M. M., Fonda, Johnstown & Gloversville.	Gloversville, N. Y.
1913	Colligan, P. J.		M. M., C. R. I. & P. Ry.	Dalhart, Tex.
1913	Coman, F. R.		M. M., Cerro de Pasco Ry.	Cerro de Pasco, Peru, S. A.
1911	Combs, W. B.		M. M., Macon, Dublin & Savannah R. R.	Macon, Ga.
1906	Conners, Jas. J.		M. M., C. M. & St. P. Ry.	Dubuque, Iowa.
1912	Conniff, P.		S. S., B. & O. R. R.	Connellsville, Pa.
1890	Conolly, J. J.		S. M. P., D. S. S. & A. R. R.	Marquette, Mich.
1908	Cook, T. R.		C. E., Willard Storage Battery Company.	Cleveland, Ohio.
1904	Cooper, F. R.		J. McKay Company	Pittsburgh, Pa.
1912	Cooper, V.		Care Galena Signal Oil Co.	Buenos Aires, Arg. Rep.
1902	Cota, A. J.		M. M., C. B. & Q. R. R.	Chicago, Ill.
1904	*Coutant, M. R.*	*29*	*M. M., Ulster & Delaware*	*Rondout, N. Y.*
1913	Cox, M. F.		M. E., L. & N. R. R.	Louisville, Ky.
1910	Cox, R. G.		M. M., S. & N. W. Ry.	Springfield, Ga.
1915	Crandall, W. J.		M. M., N. Y. C. R. R.	Rochester, N. Y.
1915	Crawford, C. H.		A. E. M. D., N. C. & St. L. R. R.	Nashville, Tenn.
1900	Crawford, D. F.		G. S. M. P., Penna. Lines (West)	Pittsburgh, Pa.
1904	Cromwell, Oliver C.		M. E., Baltimore & Ohio R. R.	Baltimore, Md.
1915	Cross, C. W.		Care of Equipment Improvement Co.	531 Ry. Ex., Chicago, Ill.
1910	Cross, J. W.		Supt. L. Dept., Park Falls Lumber Co.	Park Falls, Wis.
1893	Cross, W.			Winnipeg, Man., Can.
1911	*Crownover, G. M.*	*294*	*S. M. P., C. C. W. Ry*	*Oelwein, Iowa.*
1906	Cunningham, D. W.		Supt. Mach., Mo. Pac. Ry.	Little Rock, Ark.
1915	Cunningham, G. F.		M. M., Miss., Ark. & Western Ry.	Blissville, Ark.
1913	Cunningham, J. L.		M. M., P. W. & B. R. R.	Wilmington, Del.
1900	Curley, M. S.			1020 Patton st., Memphis, Tenn.
1903	*Curry, H. M.*	*1356*	*S. M. P., Northern Pacific Ry*	*St. Paul, Minn.*
1903	Curtis, Theo. H.			1323 Peoples Gas Bldg., Chicago, Ill.
1904	Cutler, T. J.		M. M., Northern Pacific Ry. Co.	Spokane, Wash.
1913	Cyr, J. W.		S. M. P., C. B. & Q. R. R.	Chicago, Ill.

1915	Daily, C. B.		M. M., Rock Island Lines	Cedar Rapids, Iowa.
1913	Daley, J. H.		M. M., N. Y. N. H. & H. R. R.	Taunton, Mass.
1912	Daley, W. W.		M. M., New York, Ont. & West. Ry.	Norwich, N. Y.
1909	Dalton, Wm.		Chief Engr., American Locomotive Co.	Schenectady, N. Y.
1913	Dalzell, H. E.		S. M. P., Southern Ry. of Peru	Arequipa, Peru.

JOINED.	NAME.	NO. OF LOCOS.	ROAD.	ADDRESS.
1915	Danver, W. E.		M. M., Rock Island Lines	Amarillo, Tex.
1911	Darlow, A. M.		S. M. P., Buffalo & Susquehanna R. R.	Galeton, Pa.
1912	Davery, Thos. S.		M. M., N. Y. S. & W. Ry	Stroudsburg, Pa.
....	Davies, F. D.		E., Felix Vendesmet, Usina Brasileiro	Atlanta-Maccio, Brazil.
1900	Davis, W. P.		M. M., N. Y. C. R. R.	Brewster, N. Y.
1914	Davis, W. H.		M. M., M. & E. T. Ry	Marshall, Tex.
1906	Davis, D. E.			46 Everett st., Medford, Mass.
1911	Davis, John E.		M. M., Hocking Valley R. R.	Columbus, Ohio.
1909	Davis, J. H.		Elec. Engr., B. & O. R. R.	Baltimore, Md.
1900	*Davisson, F. E.*	169	*S. M. P., San Pedro, Los Angeles & Salt Lake R. R.*	*Los Angeles, Cal.*
1897	*Dawson, E.*	10	*M. M., Ariz. & New Mexico R. R.*	*Clifton, Ariz.*
1910	*Dawson, L. L.*	88	*S. M. P., Ft. Worth & Denver City Ry*	*Childress, Tex.*
1914	Deaner, C. F.		M. M., N. Y. C. R. R.	Utica, N. Y.
1914	Deates, G. W.		M. M., Tex. & Pac. R. R.	Fort Worth, Tex.
1891	Deems, J. F.		Prest., Ward Equipment Co	141 Cedar st., New York.
1905	Deeter, D. H.		M. M., Philadelphia & Reading Ry	Reading, Pa.
1897	Delaney, C. A.			
1899	Delano, F. A.		Prest., C. I. & L. Ry	Chicago, Ill.
1900	*Demarest, T. W*	1148	*S. M. P., Pennsylvania Lines (West)*	*Ft. Wayne, Ind.*
1905	Desmond, D. G.		M. M., Morgantown & Kingwood R. R.	Morgantown, W. Va.
1909	Depue, G. T.		G. S., Erie R. R.	Galion, Ohio.
1903	Deverell, A. C.		Asst. S. M. P., Great Northern Ry	St. Paul, Minn.
1907	DeVoy, J. F.		A. S. M. P., C. M. & St. P. Ry	West Milwaukee, Wis.
1896	Dickerson, S. K.			Montreal, Que.
1902	Dickson, Geo.			1837 Selby ave., St. Paul, Minn.
1905	Dickson, John		G. M. M., S. P. & S. Ry	Portland, Ore.
1907	Diehr, C. P.		M. M., N. Y. C. R. R.	Jersey Shore, Pa.
1900	Dillon, S. J.		M. M., Pennsylvania R. R. Co	Camden, N. J.
1905	Dinan, Arthur		M. S., A. T. & S. F. Ry	Amarillo, Tex.
1905	Dinkel, M. C.			926 So. 13th st., Springfield, Ill.
1904	Dolan, J. P.		M. M., Apalachicola Ry	Port St. Joe, Fla.
1913	Dixon, A.		General Foreman, Can. Pac. Ry	Toronto, Ont., Can.
1898	Dolan, S. M.		Ala. Gt. So. Ry	915 Olive st., St. Louis, Mo.
1904	*Dooley, W. H.*	339	*C. N. O. & T. P. Ry*	*Cincinnati, Ohio.*
1912	Doud, W.		S. E., Belt Ry	Chicago, Ill.
1911	Dougherty, W. Q.		M. M., M. & O. R. R.	Jackson, Tenn.
1893	Dow, Jas. M.			Kenton, Ohio.
1908	Dresser, K. L.			
1893	Drury, M. J.		S. S., A. T. & S. F. Ry	Topeka, Kan.
1911	Duffey, G. J.		M. M., Lake Erie & Western Ry	Lima, Ohio.
1912	Dunbar, W. O.		Asst. Engr., Pennsylvania R. R.	Altoona, Pa.
1904	Dunham, W. E.		Supvr. M. P. & M., C. & N. W. Ry	Winona, Minn.
1910	Dunlap, W. H.		M. M., Louisville & Nashville R. R.	Covington, Ky.
1896	Dunn, Jas. F.			Salt Lake City, Utah.
1906	Durham, Harry P.		S. M. P. & M., Tehuantepec National	Rincon, Ant., Oxaca, Mex.
1906	Durrell, D. J.		M. M., Pennsylvania Lines (West)	Cincinnati, Ohio.

1915	Eddy, W. J.		M. M., Rock Island Lines	El Dorado, Ark.
1899	Egan, J. A.			850 W. 37th st., Los Angeles, Cal.
1906	Edmonds, Geo. S.		S. S., Delaware & Hudson	Watervliet, N. Y.
1905	Edmondson, W. G.			Titusville, Pa.
1909	Edwards, J. B.		M. M. Co., Newberry & Laurens R. R.	Columbia, S. C.

JOINED.	NAME.	NO. OF LOCOS.	ROAD.	ADDRESS.
1912	Eich, H. C		M. M., Ill. Cent. R. R	Chicago, Ill.
1906	Elliott, J. B			
1910	*Elmer, Wm*	353	S. M. P., Pennsylvania R. R	Buffalo, N. Y.
1914	Elmes, C. C		A. E., P. & R. Ry	Reading, Pa.
1915	Embury, W. B		M. M., Rock Island Lines	Valley Jct., Iowa.
1901	Emerson, Geo. H		G. M., Great Northern Ry	St. Paul, Minn.
1906	Emerson, Harrington			30 Church st., New York City.
1911	Emory, John B		M. M., Texarkana & Ft. Smith Ry	Texarkana, Tex.
1893	English, Richard			77 Liberty st., San Francisco, Cal.
1905	*Enright, J. F*	617	*S. M. P., D. & R. G. R. R*	*Denver, Colo.*
1898	Ettenger, R. L		C. M. E., M. & O. R. R	Washington, D. C.
1908	Evans, G. I		M. E., Can. Pac. Ry	Montreal, Angus Shops, Que., Can.
1914	*Ewald, Wm*	26	*S. M. P., Cumberland & Penna. R. R*	*Mt. Savage, Md.*
1900	Ewing, J. J		M. E., C. & O. Ry. Co	Richmond, Va.
1913	Fagan, J. L		M. M., D. & R. G. R. R	Grand Junction, Colo.
1905	Ferguson, L. B		M. M., Vicksburg, Shreveport & Pacific	Monroe, La.
1904	Ferguson, T. G		Wks. Mgr., Cordoba Cent. Ry	Cordoba, Lalleres, Arg. Rep.
1914	Ferry, F. C		Works Mgr., Cordoba Central Ry	Cordoba Lalleres, Arg. Rep., S. A.
1904	Fetner, W. H		M. M., Central of Georgia Ry	Macon, Ga.
1912	Finegan, L		D. M. M., B. & O. R. R	Glenwood, Pittsburgh, Pa.
1909	Fitzgerald, D. W		The Texas Co	St. Louis, Mo.
1905	Fitzgerald, W. T		M. M., Rock Island Lines	Estherville, Iowa.
1892	Fitzmorris, Jas		M. M., Chicago Junction Ry	Chicago, Ill.
1908	Fitzsimmons, E. S		M. S., Erie R. R	Cleveland, Ohio.
1912	Flanagan, M		M. M., Chesapeake & Ohio Ry	Richmond, Va.
1906	*Flavin, J. T*	145	*M. M., C. I. & S. R. R*	*Kankakee, Ill.*
1903	*Flory, B. P*	212	*S. M. P., N. Y. O. & W. R. R*	*Middletown, N. Y.*
1909	*Flynn, W. H*	756	*S. M. P., Mich. Cent. R. R*	*Detroit, Mich.*
1901	*Fogg, J. W*		*Boss Nut Co*	*Chicago, Ill.*
1896	*Foque, T. A*	537	*S. M. P., M. St. P. & S. S. M. Ry*	*Minneapolis, Minn.*
1912	Foster, E. W			2424 Clay st., Denver, Colo.
1908	Foster, O. M		M. M., N. Y. C. R. R	Cellinwood, Ohio.
1908	Foster, W. H		M. M., N. Y. C. R. R	High Bridge, New York City.
1904	Foster, W. T			Seffner, Fla.
1877	Fowle, I. W			Riverside, Cal.
1907	Fowler, Henry		C. M. E., Midland Ry. of England	Derby, Eng.
1906	Franey, M. D		M. M., N. Y. C. R. R	Elkhart, Ind.
1907	Fraps, J. C			
1907	*Fraser, Thos*	33	*M. M., Algoma Central Ry*	*Sault Ste. Marie, Ont., Can.*
1914	Freeman, L. D		S. S., Seaboard Air Line Ry	Portsmouth, Va.
1906	French, G. W		M. M., Mo. Pac. Ry	Paragould, Ark.
1891	French, R. E			1840 9th ave., Oakland, Cal.
1906	Freire, da Silva, J. J		S. M. P., Central Ry. of Brazil	Rio de Janeiro, Brazil, S. A.
1904	Fries, A. J		A. S. M. P., N. Y. C. R. R	Depew, N. Y.
1903	Fryburg, F. M		G. M. M., Great Northern Ry	Great Falls, Mont.
1890	*Fuller, C. E*	822	*S. M. P., Union Pacific R. R*	*Omaha, Neb.*
1907	Fulmor, John H		M. M., Pennsylvania R. R	Pottsville, Pa.
1897	*Gaines, F. F*	336	*S. M. P., Central of Georgia Ry*	*Savannah, Ga.*
1904	Gairus, A. H		Supt., Central Locomotive & Car Works	Chicago, Ill.

JOINED.	NAME.	NO. OF LOCOS.	ROAD.	ADDRESS.
1914	Gallagher, G. A		M. M., Ill. So. R. R	Sparta, Ill.
1915	Gallaway, A. K		M. M., B. & O. R. R	Riverside, Baltimore, Md.
1904	Galloway, W. S		M. M., B. & O. R. R	Camden Sta., Baltimore, Md.
1911	Gardner, G. Clinton		G. F. M. P., Pennsylvania R. R	Buffalo, N. Y.
1910	Gardner, Henry		A. S. A., B. & O. R. R	Baltimore, Md.
1908	Gaspar, Charles L		National Malleable Castings Co	St. Louis, Mo.
1915	Gaston, J. H		National Malleable Castings Co	1859 Ry. Ex., St. Louis, Mo.
1915	Gelhausen, F. R		G. F., B. & O. R. R	Garrett, Ind.
1886	Gentry, T. W		American Locomotive Co	Richmond, Va.
1914	George, W. A		S. S., A. T. & S. F. Ry	Albuquerque, N. M.
1899	Gibbs, A. W		C. M. E., Pennsylvania R. R. Co	Philadelphia, Pa.
1890	Gibbs, Geo		Penna. Station	New York City.
1909	Gibbs, J. W		M. M., Virginia & Southwestern Ry	Sheffield, Ala.
1911	*Giles, C. F*	1060	*S. M., Louisville & Nashville R. R*	*Louisville, Ky.*
1914	Gill, C. A		G. M. M., Balt. & Ohio R. R	Baltimore, Md.
1896	Gill, John		Amer. Loco. Co	Dunkirk, N. Y.
1891	Gillis, H. A			Home Life Bldg., Washington, D. C.
1914	Gillespie, H. C		M. M., Ches. & Ohio Ry	Peru, Ind.
1913	Givin, E. F		M. E., P. S. & N. R. R	St. Marys, Pa.
1893	Gilmour, Geo		Supt. Insp., Travelers Ins. Co	Hartford, Conn.
1891	Glass, John C		M. M., Pennsylvania R. R	Verona, Pa.
1905	Goodale, R. J			804 6th st., Wichita Falls, Tex.
1911	Goodall, C. N		Mgr., Robt. Stephenson & Co	Darlington, Eng.
1905	Goodrich, M		M. M., N. Y. C. R. R	Ottawa, Ont., Canada.
1915	Goodwin, Geo. S		M. E., C. R. I. & O. Ry	Chicago, Ill.
1880	Gordan, H. D			80 White st., New York City.
1909	Gorey, E. H		G. F., Louisville & Nashville R. R	Paris, Ky.
1900	Gould, Jos. E			
1904	*Gould, J. R*	830	*S. M. P., Chesapeake & Ohio Ry*	*Richmond, Va.*
1899	Gould, Robt			Pinecroft, Pyrford, near Woking, Eng.
1911	Graburn, A. L		M. E., Can. Nor. Ry	Toronto, Ont., Can.
1892	Graham, Chas., Jr			845 Quincy ave., Scranton, Pa.
1912	Graham, Ernest		C. A. S., Great Western Ry	Jaboatao, Pernambuco, Brasil, S. A.
1894	Graham, J. A			2052 E. 88th st., Cleveland, Ohio.
1903	Grandy, W. S		Div. For., Atchison, Topeka & Santa Fe	Bakersfield, Cal.
1906	*Gray, B. H*	58	*N. O. M. & C. R. R*	*Mobile, Ala.*
1906	*Gray, G. M*	178	*S. M. P., B. & L. E. R. R*	*Pittsburgh, Pa.*
1897	Greaven, Louis		S. M. P., Buenos Aires Great Southern	Buenos Aires, Arg. Rep.
1889	Greatsinger, J. L		2d V.-P. Elmira, Corning & Waverly Ry	Elmira, N. Y.
1911	Gregory, C. F		M. M., Manufacturers Ry. of St. Louis	St. Louis, Mo.
1905	Green, H			Peoples Gas Bldg., Chicago, Ill.
1905	Greenwood, B. E		E. P. H., N. & W. Ry	Roanoke, Va.
1909	Greenwood, H. F		Genl. For., Norfolk & Western Ry	Roanoke, Va.
1915	Griffith, W. G		M. M., Pere Marquette Ry	Saginaw, Mich.
1908	Grimshaw, F. G		A. E. M. P., Penna. R. R	Pittsburgh, Pa.
1908	Gross, E. G		M. M., Central of Georgia Ry	Columbus, Ga.
1898	Gross, R. J		U. S. Radiator Co	Dunkirk, N. Y.
1914	Grove, P. L		M. M., Penna. R. R	Sunbury, Pa.
1896	Groves, J. R		S. M. P., Colo. Midland Ry	Colorado Springs, Colo.
1900	Gurry, Geo		Amer. Loco. Co	Richmond, Va.

1910	Haig, M. H		M. E., A. T. & S. F. Ry	Topeka, Kan.
1893	*Hainen, J*	1,756	*G. S. M. P., So. Ry., V. & S. W. Ry., N. A. Ry*	*Washington, D. C.*

JOINED.	NAME.	NO. OF LOCOS.	ROAD.	ADDRESS.
1906	Hale, H. H			799 Geary st., San Francisco, Cal.
1913	Hale, O. R		M. M., United Rys. of Havana Western Ry	Cienaga, Havana.
1904	Hall, Charles S		M. M., Boston & Maine R. R	Concord, N. H.
1908	*Hamilton, Taber*	*64*	*M. M., Cumberland Valley R. R*	*Chambersburg, Pa.*
1907	Hamilton, Wm. H			402 W. 6th st., Chanute, Kan.
1902	Hammett, Philip M		S. M. P., Maine Central R. R. Co	Portland, Me.
1891	Hancock, Geo. A			Springfield, Mo.
1912	Hanks, F. F		M. M., Georgetown & Western Ry	Georgetown, S. C.
1898	Hanlin, J. J		M. M., Seaboard Air Line Ry	Atlanta, Ga. (Howell Sta.).
1909	Hardie, Henry		M. M., Louisville & Nashville R. R	Howell, Ind.
1905	Harkom, John W			Melbourne, Que., Can.
1906	Harrington, H. H		M. M., Erie R. R	Susquehanna, Pa.
1914	Harris, A. A		M. M., N. Y. N. H. & H. R. R	East Hartford, Conn.
1907	Harris, C. M		M. M., Washington Terminal R. R	Washington, D. C.
1912	Harris, E. J		M. M., C. R. I. & P. Ry	Armourdale, Kan.
1912	*Harris, H. Y*	*8*	*M. M., Tampa Nor. R. R*	*Odessa, Fla.*
1902	Harris, J. D			Muskogee, Okla.
1898	*Harrison, F. J*	*323*	*S. M. P., B. R. & P. Ry*	*Du Bois, Pa.*
1903	Hartigan, Bert		Genl. For., Rutland R. R	Rutland, Vt.
1914	Hartman, O. G		M. M., Wis. & Michigan Ry	Peshtigo, Wis.
1913	Hartman, W. J		A. B. Instr., C. R. I. & P. Ry	Chicago, Ill.
1901	Haselton, G. H		Gen. Loco. Supt., N. Y. C. R. R	New York City, N. Y.
1899	Haskell, B			Franklin, Pa.
1913	Haskins, E. G		M. M., Denver & Rio Grande R. R	Salida, Colo.
1910	Hassett, M. W		M. M., N. Y. C. Lines	East Buffalo, N. Y.
1910	Hatch, M. C. M		S. F. S., D. L. & W. R. R	Scranton, Pa.
1905	Hatz, G. K		M. M., Union Pacific R. R	Omaha, Neb.
1909	Haug, Harry		M. M., Brownstone & Middleton Ry	Waltonville, Pa.
1900	Hawkins, B. H		M. M., B. & O. R. R	Grafton, W. Va.
1903	Hawkins, R. D		S. M. P., Great Northern Ry	St. Paul, Minn.
1908	Hayes, C. W		M. M., Blue Ridge Ry	Anderson, S. C.
1906	Hayes, John T		M. M., Grand Rapids & Indiana Ry	Grand Rapids, Mich.
1903	Hayes, W. C		S. L. O., Erie R. R	New York, N. Y.
1906	Hayward, H. S		S. M. P., Pennsylvania R. R. Co	Jersey City, N. J.
1891	Hedley, F		G. M., Interborough R. T. Ry	New York, N. Y.
1887	*Heintzelman, T. W.*	*1,410*	*G. S. M. P., So. Pac. Co*	*San Francisco, Cal.*
1911	Heiser, W. F		M. M., C. & E. I. R. R	Evansville, Ind.
1892	Henderson, Geo. R		Baldwin Loco. Works	500 N. Broad st., Philadelphia, Pa.
1910	*Henry, J. M*	*1,050*	*S. M. P., Pennsylvania R. R*	*Pittsburgh, Pa.*
1907	Henry, Wm		M. M., St. L. & S. F. R. R	Monett, Mo.
1908	*Henry, W. C. A*	*780*	*S. M. P., Pennsylvania Lines (West)*	*Columbus, Ohio.*
1912	Henshaw, J. E		S. S., St. L. & S. F. R. R	Springfield, Mo.
1907	Herr, E. E		M. M., Pennsylvania R. R	Camden, N. J.
1908	*Hess, Geo. F*	*195*	*S. M., K. C. Southern Ry*	*Pittsburg, Kan.*
1906	Hicks, I. C		M. M., A. T. & S. F. Ry	San Bernardino, Cal.
1911	Hickson, Thos		M. M., C. M. & G. Ry	Rockford, Ill.
1915	Highleyman, J. W		M. M., Union Pac. R. R	Cheyenne, Wyo.
1890	Higgins, Sam'l			
1901	Hildreth, Fred F		M. E., Vandalia R. R	Terre Haute, Ind.
1901	Hilferty, Chas. D			P. O. Box 34, Chautauqua, N. Y.
1913	Hill, A. J		B. C. & W. Supt., Great Eastern Ry	Stratford, London, Eng.
1913	Hill, J. F		M. M., W. & L. E. R. R	Brewster, Ohio.
1904	*Hill, W. H*	*6*	*M. M., Cornwall R. R*	*Lebanon, Pa.*
1902	Hillman, C. R		Asst. S. M. P., San Paulo Ry	San Paulo, Brazil, S. A.
1902	Hobson, W. P		M. M., C. & O. Ry	Covington, Ky.

JOINED.	NAME.	NO. OF LOCOS.	ROAD.	ADDRESS.
1904	Hodgins, G. S			390 Wadsworth ave., New York City.
1906	Hoffman, C. M		M. M., S. P. L. A. & S. L. R. R	Milford, Utah.
1908	Hoffmaster, F. S		A. M. M., N. Y. P. & N. R. R	Cape Charles, Va.
1901	Hogan, C. H		A. S. M. P., N. Y. C. & H. R. R. R	32 Union Sta., Albany, N. Y.
1914	Hogwood, J. T		M. M., Tex. City Terminal Co	Texas City, Tex.
1915	Hohensteiner, E. H		G. B. I., Rock Island Lines	Silvis, Ill.
1912	Hoke, H. A		Asst. Engr. M. E. Dept., Penna. R. R	Altoona, Pa.
1892	Holland, W. D			210—55 Wall st., New York.
1896	Hopwood, John		Bolivia Ry	Oruro, Bolivia.
1896	*Horrigan, John*	257	*S. M. P., E. J. & E. R. R. Co*	*Joliet, Ill.*
1906	Horsey, A. W		M. M., Can. Pac. Ry	Montreal, Can.
1892	Howard, C. H			1629 Pierce Bldg., St. Louis, Mo.
1896	Howard, Jno		S. M. P., N. Y. C. R. R	610 Grand Centl. Terml., New York.
1899	Hudson, H. G			68 Grasmere ave., East Cleveland, Ohio.
1906	Hungerford, S. J		S. M. P., Can. Nor. R. R	Winnipeg, Man.
1905	Hume, E. S		Chief Mech. Engr., West. Australian Govt. Rys	Midland Jct., Australia.
1890	Humphrey, A. L		G. M., Westinghouse Air Brake Co	Pittsburgh, Pa.
1904	Hunt, Harry B		American Locomotive Co	New York.
1905	Hunter, H. S		M. M., Philadelphia & Reading Ry	Philadelphia, Pa.
1911	Hunter, W. C			
1915	Hyde, R. C		M. M., Rock Island Lines	Manly, Iowa.
1896	*Hyndman, F. T*	208	*S. M. P., W. & L. E. R. R*	*Brewster, Ohio.*
1913	Inglesh, H. O		C. E., So. Western Portland Cement Co	El Paso, Tex.
1912	Irvin, I. B		G. F., P. S. & N. Ry	Angelica, N. Y.
1913	Irvin, J. J		S. M. P., H. S. Kerbaugh, Inc	Bellwood, Pa.
1900	Irwin, J. E			519 No. Main st., Tulsa, Okla.
1907	Jackson, Harry			
1911	Jackson, H. D		M. M., Charlotte Harbor & Northern	Arcadia, Fla.
1911	*Jackson, O. S*	73	*S. M. P., C. T. H. & S. E. Ry*	*Terre Haute, Ind.*
1911	Jackson, W. S			99 Delmont ave., Cleveland, Ohio.
1915	Jackson, R. E			99 Delmont Ave., Cleveland, Ohio.
1908	Jacobs, H. W			117 Greenwood ave., Topeka, Kan.
1912	Jacobs, L. M		M. M., Houston Belt & Ter. Ry	Houston, Tex.
1907	James, Charles		M. M., Erie R. R	Jersey City, N. J.
1899	James, E. T		Supt. Shops, Lehigh Coal & Nav. Co	Lansford, Pa.
1910	James, J. M		A. S., Pennsylvania R. R	Youngwood, Pa.
1907	Jaynes, R. T		M. M., Lehigh & Hudson River Ry	Warwick, N. Y.
1900	Jennings, Thos		M. M., B. & M. R. R	Concord, N. H.
1896	Johnson, A. B		Prest., Baldwin Locomotive Works	Philadelphia, Pa.
1910	Johnson, Frank		M. M., Southern Ry	Birmingham, Ala.
1887	Johnson, L. R		Canadian Pacific Ry	Montreal, Can.
1914	Johnston, H. W		S. M. & H. T., B. & O. R. R	Baltimore, Md.
1909	Johnston, J. M		Fuel Agt., St. L. & S. F. Ry	St. Louis, Mo.
1910	Jones, C. H		M. M., Huntingdon & Broad Top Mtn	Saxton, Pa.
1909	Jones, E. F		M. M., C. & W. I. R. R., Belt Ry. of Chicago	Chicago, Ill.
1913	Jones, L. B		A. E. M. P., Penna. Lines, West	Columbus, Ohio.
1888	Joughins, G. R		M. S., Intercolonial Ry	Moncton, N. B.
1896	Justice, D. J			3406 W. Broadway, Louisville, Ky.

JOINED.	NAME.	NO. OF LOCOS.	ROAD.	ADDRESS.
1905	*Kaderly, W. F.*	65	*S. M. P., Ga. So. & Fla. Ry.*	*Macon, Ga.*
1890	*Kalbaugh, I. N.*	30	*S. M. P., Coal & Coke Ry.*	*Gassaway, W. Va.*
1912	Kantmann, A. G.		A. M. M., N. O. & N. E. R. R.	Meridian, Miss.
1903	*Kapp, W. F.*	83	*Supt. Shops and Machy., R. F. & P. Ry.*	*Richmond, Va.*
1907	Kastlin, Jacob		Supt., Davenport Locomotive Works	Davenport, Iowa.
1904	Kearney, Alexander		Asst. S. M. P., N. & W. Ry.	Roanoke, Va.
1892	Keegan, Jas. E.		S. M. P., G. R. & I. R. R.	Grand Rapids, Mich.
1909	Keenan, C. E.		Care of Worth Bros. Co.	50 Church st., New York City.
1910	Keiser, C. B.		M. M., Penna. R. R. (Penna. Tunnel & Term. Div.)	New York City.
1915	Kelley, F. D.		M. M., National Ry. of Haiti	St. Marc, Haiti, W. I.
1911	Kellogg, D. P.		S. S., Southern Pacific Ry.	Los Angeles, Cal.
1904	*Kellogg, W. L.*	689	*S. M. P., M. K. & T. Ry.*	*Denison, Tex.*
1896	Kells, Willard		S. M. P., Atlantic Coast Line R. R.	Wilmington, N. C.
1914	Kelly, J. P.			
1914	Kelly, O. J.		M. M., Balt. & Ohio R. R.	Newark, Ohio.
1904	Kendig, R. B.		G. M. E., N. Y. C. Lines	New York, N. Y.
1913	Kendrick, J. P.		M. M., B. R. & P. Ry.	Punxsutawney, Pa.
1901	Keyworth, T. E.		Cuban Central Rys., Ltd.	Sagua la Grande, Cuba.
1910	Kiesel, W. F., Jr.		Asst. M. E., Pennsylvania R. R.	Altoona, Pa.
1911	Kight, H. R.		M. M., Western Maryland R. R.	Elkins, W. Va.
1903	Kilpatrick, J. B.			644 Ry. Exchange, Chicago, Ill.
1900	Kilpatrick, R. F.			64 No. 5th st., Newark, Ohio.
1911	Kinney, C. D.			
1909	*Kinney, M. A.*	156	*S. M. P., Hocking Valley Ry.*	*Columbus, Ohio.*
1905	Kinney, W. H.		M. M., N. Y. O. & W. Ry.	Carbondale, Pa.
1909	Kipp, A. R.		M. S., M. St. P. & S. S. M. Ry.	Fond du Lac, Wis.
1904	Kirkpatrick, James		M. M., B. & O. R. R.	Riverside, Md.
1902	Knight, George E.		G. M. M., Cuba R. R.	Camaguey, Cuba.
1908	Knight, W. E.		S. M. P. & S., Cuba R. R.	Camaguey, Cuba.
1911	Kobyashi, S.			17 Madison ave., New York City.
1914	Kothe, C. A.		M. M., Erie R. R.	Marion, Ohio.
1911	Krassovsky, P.		A. G. S. M. P., Moscow-Kasan R. R.	Moscow, Russia.
1912	Kuhn, B. F.		A. M. M., N. Y. C. R. R.	Collinwood, Ohio.
1912	Kuhn, W. T.		S. M. P., Toronto, Hamilton & Buffalo	Hamilton, Ont., Can.
1907	Kurman, A. G.		M. M., Mt. Jewett, Kinzua & Riterville	Kane, Pa.
1905	Kyle, C.		M. M., Canadian Pacific Ry.	Montreal, Can.

1899	Lachlan, Wm.			37 Philbeach Gardens, Earls Court, London, S. W., Eng.
1913	Ladley, W. E.		S. M. P., Reid Newfoundland Co.	St. Johns, Newfoundland.
1912	Laisure, L. R.		M. M., Erie R. R.	Hornell, N. Y.
1909	Lancaster, T. C.		Gen. For., Southern Ry.	Birmingham, Ala.
1888	Lape, C. F.			216 Stimson Block, Los Angeles, Cal.
1912	Latham, C. E.			30 W. 5th st., Peru, Ind.
1911	Laughton, G. H.			
1914	Laux, J. P.		M. M., Lehigh Valley R. R.	Hazleton, Pa.
1910	Lavallee, J. L.			719 Mason st., San Antonio, Tex.
1891	Lawes, T. A.		M. E., N. Y. C. & St. L. R. R.	Cleveland, Ohio.
1914	Layden, T. E.		A. E. T., A. T. & S. F. Ry.	Topeka, Kan.
1890	Leach, H. L.			107 Thorndike st., Brookline, Mass.
1903	Leach, W. B.			383 Dorchester ave., South Boston, Mass.
1892	Lee, C. W.			223 South Spring st., Greensboro, N. C.
1890	Leonard, A. G.		Chicago Junction Ry.	Chicago, Ill.
1912	Lewis, M. W.		M. M., Okla. Cent. R. R.	Purcell, Okla.

JOINED.	NAME.	NO. OF LOCOS.	ROAD.	ADDRESS.
1876	*Lewis, W. H*	1,050	*S. M. P., N. & N. W. Ry. Co*	*Roanoke, Va.*
1909	Leyonmark, J. H		M. E., Chicago & Alton Ry	Bloomington, Ill.
1912	Lide, C. D		M. M., Carolina & Northwestern Ry	Hickory, N. C.
1909	Likert, G. H			Railway Exchange, Chicago, Ill.
1907	Lillie, G. W			81 S st., Salt Lake City, Utah.
1904	Link, Truman C			
1909	Little, J. C		M. E., C. & N. W. Ry	Chicago, Ill.
1903	Litton, Francis Henry		Care of Hull & Barnsley Ry	Springhead, Hull, Eng.
1913	Lloyd, L. N		A. C. & W. S., Bombay, Baroda & Cent. India Ry	Ajmer, Rajputana, India.
1905	Lockwood, B. D		A. C. E., Pressed Steel Car Co	McKee's Rocks, Pa.
1907	Lord, Alfred W		S. M. P., Quincy & Torch Lake R. R	Hancock, Mich.
1899	Lovell, Alfred			819 Harrison Bldg., Philadelphia, Pa.
1911	Lovell, F. A		Care J. F. Berndes & Co	Cuba 64, Havana, Cuba.
1911	Lucy, Ernest Edward		C. M. E., New South Wales Govt. Rys	Sydney, N. S. W.
1913	Luscombe, J. T		M. M., B. & O. R. R	Parkersburg, W. Va.
1910	Lynch, J. M		M. M., Honduras Ry	Honduras, Puerto, Cortes, C. A.
1894	Lyon, T			88 Congress st., E., Detroit, Mich.

JOINED.	NAME.	NO. OF LOCOS.	ROAD.	ADDRESS.
1903	*MacBain, D. R*	995	*S. M. P., N. Y. C. R. R*	*Cleveland, Ohio.*
1915	MacBeth, A		S. M. P., N. Y. C. & St. L. R. R	Cleveland, Ohio.
1915	*MacBeth, H. A*	244	*S. M. P., N. Y. C. & St. L. Ry*	*Cleveland, Ohio.*
1899	Machesney, A. G		Detroit Lubricator Co	Detroit, Mich.
1909	Machovec, E. E		D. M. M., Santa Fe	Argentine, Kan.
1876	Mackenzie, John			325 Citizens Bldg., Cleveland, Ohio.
1905	Magarvey, John R		Supt., American Locomotive Co	Dunkirk, N. Y.
1911	Mahar, Thos		M. M., N. Y. C. R. R	White Plains, N. Y.
1896	Maher, P			1501 E. Washington st., Bloomington, Ill.
1896	Mahl, F. W		Dir. of Pur., So. Pac. Co	New York City.
1915	Main, D. T		S. M. P., Can. Pac. Ry	Montreal, Can.
1899	Mahoney, W. H		Care Galena-Signal Oil Co	Buenos Aires, Arg. Rep.
1899	Malone, I. M		Care United Fruit Co	Puerto Barrios, Guatemala, C. A.
1904	Malthaner, W		M. M., Delaware & Hudson Co	Green Island, N. Y.
1894	*Manchester, A. E*	1,978	*S. M. P., C. M. & St. P. Ry*	*Milwaukee, Wis.*
1902	*Manchester, H. C*	760	*S. M. P., D. L. & W. R. R*	*Scranton, Pa.*
1914	*Manley, Chas*	27	*M. M., M. & N. A. R. R*	*Harrison, Ark.*
1893	*Manning, J. H*	491	*S. M. P., D. & H. Co*	*Watervliet, N. Y.*
1905	Mannion, T. D		M. M., Atlantic City R. R	Camden, N. J.
1898	Marchbanks, Jas		Eng., Wellington Harbour, Board Wellington	New Zealand.
1908	Marea, M		M. M., St. Louis, Troy & Eastern Ry	St. Louis, Mo.
1914	Marriott, J. F		C. D., C. & O. R. R	Richmond, Va.
1910	Marsh, F. E		A. M. M., Penn. R. R. Co., Altoona, Machine Shops	Altoona, Pa.
1906	Marshall, Thos		G. M. M., C. St. P. M. & O. Ry	1145 W. 7th st., St. Paul, Minn.
1891	Marshall, W. H		American Locomotive Co	Cortlandt Bldg., 30 Church st., N. Y. C.
1908	Martin, E. L			
1910	Martin, H. W		Supt., Mt. Jewett, Kinzua & Riterville Ry	Kushequa, Pa.
1915	Mauk, E. L		M. M., Ga., Fla. & Ala. Ry	Bainbridge, Ga.
1913	Maunsell, R. E. L		C. L. E., Great Southern & Western Ry. of Ireland	Inchicon, Dublin, Ireland.
1910	Maupin, J. D		S. M. P., T. & B. V. R. R	Teague, Tex.

JOINED.	NAME.	NO. OF LOCOS.	ROAD.	ADDRESS.
1909	Maver, A. A		M. M., Grand Trunk Ry	Montreal, Can.
1909	Maxfield, H. H		M. M., Pennsylvania R. R	Trenton, N. J.
1913	Maxfield, W. E		M. M., Tex. & Pac. Ry	Big Spring, Tex.
1910	Maxwell, J. D		M. M., Louisville & Nashville R. R	Mobile, Ala.
1903	*May, H. C.*	*143*	*S. M. P., C. I. & L. Ry*	*Lafayette, Ind.*
1907	May, Walter		M. M., C. C. C. & St. L. Ry	Louisville, Ky.
1915	McAmis, W. H		M. M., Charlotte Harbor & Nor. Ry	Arcadia, Fla.
1906	McArthur, F. A		M. M., St. L. & S. F. Ry	Springfield, Mo.
1914	McBride, B		M. M., Southern R. R	Columbia, S. C.
1910	McCabe, Jos			350 E. 166th st., New York City.
1912	McCarra, M. F			Shreveport, La.
1905	McCarthy, M. J		S. M. P., C. H. & D. Ry	Cincinnati, Ohio.
1908	McCarthy, T. W		M. M., C. R. I. & P. Ry	Horton, Kan.
1891	McConnell, J. H			168 N. Sycamore st., Hollywood, Cal.
1903	McCuen, R. E		M. M., L. & E. R. R	Lexington, Ky.
1891	McDonough, Jas		M. M., Santa Fe Ry	Ft. Madison, Iowa.
1905	McDougall, R. M		M. M., Morenci Southern Ry	Morenci, Ariz.
1910	McFarland, H. B		E. T., A. T. & S. F. Ry	Ry. Exchange, Chicago.
1908	McGee, W. J		M. M., Tex. & Pac. Ry	New Orleans, La.
1905	McGoff, J. H		M. S., A. T. & S. F. Ry	Topeka, Kan.
1915	McGowan, G. W		G. R. G. F., Houston Texas Cent. R. R	Houston, Tex.
1903	McGrath, J. T			
1910	McGregor, A. A		M. M., Louisville & Nashville R. R	Boyles, Ala.
1911	McGuire, J. J		M. M., B. & O. R. R	New Castle Jct., Pa.
1912	McIlvane, C. L		M. M., N. Y. P. & M. R. R	Cape Charles, Va.
1893	*McKee, Geo. S*			*San Antonio, Tex.*
1901	McKeen, W. R., Jr		Cons. Eng. Motor Cars, Union Pacific R. R	Omaha, Neb.
1911	McLean, J. E		M. M., K. C. S. Ry	Pittsburg, Kan.
1896	McLean, W. J		M. M., Kettle Valley Ry	Penticton, B. C., Can.
1906	McManamy, John			1007 Jefferson ave., Grand Rapids, Mich.
1890	McNaughton, Jas		American Locomotive Co	Schenectady, N. Y.
1905	McNulty, F. M		S. M. P., Monongahela Connecting R. R	Pittsburgh, Pa.
1915	McPartland, C. M		M. M., Rock Island Lines	Goodland, Kan.
1915	McQuade, R. J		M. M., Rock Island Lines	Armourdale, Kan.
1914	McQuillen, J. E		M. S., G. C. & S. F. Ry	Cleburne, Tex.
1905	McRae, J. A		M. E., L. & N. R. R., Shops	So. Louisville, Ky.
1910	Meade, P. J		M. M., Atlantic Coast Line	Rocky Mount, N. C.
1907	Mechling, J. E		M. E., Vandalia R. R	Terre Haute, Ind.
1905	Meister, C. L		M. E. (Ch. Draughtsman), Atl. Coast R. R	Wilmington, N. C.
1895	Mellin, C. J		American Locomotive Co	1005 Union st., Schenectady, N. Y.
1910	Mengel, J. C		M. M., Pennsylvania R. R	Philadelphia, Pa.
1907	Meredith, Harry Parr		M. M., Penn. R. R	Sunbury, Pa.
1892	*Mertsheimer, F*	*62*	*G. S. M. P., K. C. M. & O. R. R*	*Kansas City, Mo.*
1887	Michael, J. B		M. M., Southern Ry. Co	Selma, Ala.
1890	*Miller, Geo. A*	*118*	*S. M. P., Florida East Coast Line*	*St. Augustine, Fla.*
1909	Miller, H. M		M. M., Susquehanna & New York R. R	W. Williamsport, Pa.
1903	Miller, J. B		G. F., St. L. S. W. Ry	Waco, Tex.
1913	Miller, T. E		M. M., B. & O. R. R	Connellsville, Pa.
1915	Miller, W. J		S. M. P., St. Louis So. West. Ry	Pine Bluff, Ark.
1903	*Milliken, Jas*	*328*	*S. M. P., P. B. & W. Ry*	*Wilmington, Del.*
1909	Mills, J. H		M. M., Canada Pacific Ry	West Toronto, Ont., Can.
1893	Minshull, P. H		M. M., N. Y. O. & W. R. R	Middletown, N. Y.
1907	Moll, George		P. & R. R. R	Reading, Pa.
1901	Monahan, J. J		M. M., Louisville & Nashville R. R	Paris, Tenn.

JOINED.	NAME.	NO. OF LOCOS.	ROAD.	ADDRESS.
1908	Monfee, A. J.		M. M., Birmingham Southern R. R.	Pratt City, Ala.
1890	Monkhouse, H.		Rome Locomotive & Machine Works	Rome, N. Y.
1903	Monlaverdo, F.			
1903	Monroe, M. S.		M. M., E. J. & E. Ry.	Gary, Ind.
1911	Montgomery, Chas.			St. Thomas, Ont., Can.
1907	Montgomery, H.		M. M., Pennsylvania Ry. Co.	Oil City, Pa.
1910	*Montgomery, Hugh*	*96*	*S. M. P., Rutland R. R.*	*Rutland, Vt.*
1884	Montgomery, Wm.		M. M., Central Ry. of N. J.	Lakehurst, N. J.
1910	Mooney, T. H.			820 Hayes st., San Antonio, Tex.
1910	*Monroe, B. R.*	*112*	*S. M. P., Duluth & Iron Range R. R.*	*Two Harbors, Minn.*
1896	Moran, Robt.		M. M., L. & N. R. R. Co.	Nashville, Tenn.
1913	Mori, Hikozo		C. M. E., South Manchuria Ry.	Dairen, Manchuria, China.
1909	Morehead, L. B.		M. E., C. I. & L. Ry.	Lafayette, Ind.
1907	Moriarty, G. A.		M. M., N. Y. N. H. & H. R. R.	Providence, R. I.
1915	Moseley, W. S.		M. E., C. C. & O. Ry.	Erwin, Tenn.
1915	*Moses, F. K.*	*46*	*M. M., B. & O., Chgo. Term. R. R.*	*East Chicago, Ind.*
1906	Mowery, J. N.		Keystone Lubricating Co.	Philadelphia, Pa.
1901	Muchnic, C. M.		American Locomotive Co.	111 Broadway, New York, N. Y.
1899	Muhlfeld, J. E.			Sherbrooke Road, Scarsdale, N. Y.
1905	*Mullen, D. J.*	*859*	*S. M. P., C. C. C. & St. L. Ry.*	*Indianapolis, Ind.*
1914	Mullet, H. A.		S. R. S., Milwaukee Elec. Ry. & Light Co.	Milwaukee, Wis.
1908	Mullinix, S. W.		S. S., C. R. I. & P. Ry.	Silvis, Ill.
1913	Murphy, F. K.		A. S. M. P., C. C. C. & St. L. Ry.	Indianapolis, Ind.
1890	Murphy, P. H.			Frick Bldg., Pittsburgh, Pa.
1912	Murray, E. A.		M. M., Chesapeake & Ohio Ry.	Clifton Forge, Va.
1915	Murry, F. H.		M. M., Erie R. R.	81 Pavonia Ave., Jersey City N. J.
1903	Murrian, W. S.		S. M. P., Southern Ry.	Knoxville, Tenn.
1909	Myers, B. P.		D. M. M., Int. & Gt. Nor. Ry.	San Antonio, Tex.
1910	Nash, J. H.		Shop Supt., Illinois Central R. R.	Chicago, Ill.
1904	Needham, E. F.		S. L. & C. D., Wabash R. R.	Springfield, Ill.
1908	Neel, T. M., Jr.			643 Woodward ave., McKee's Rocks, Pa.
1911	Nelson, C. B.		A. M. M., N. Y. C. R. R.	Elkhart, Ind.
1905	Nelson, E. D.		E. T., Penna. R. R.	Altoona, Pa.
1915	Neuffer, J. G.		Care of Hide Park Hotel	Chicago, Ill.
1901	Neville, John			
1908	New, W. E.		M. M., K. C. Belt Ry.	Kansas City, Mo.
1913	Newcomb, T. H. Y.		S. M., Jefferson & No. West. Ry.	Jefferson, Tex.
1899	Nolan, J. P.		A. S., Mor. L. & T. R. R. & S. S. Co.	Algiers, La.
1906	Noyes, Charles T.		Supt. Shops, Southern Pacific Co.	Sacramento, Cal.
1896	Nuttall, W. H.		S. M. P., Manistee & North Eastern Ry.	Manistee, Mich.
1914	O'Brien, W. J.		Kanawha & Michigan R. R.	Hobson (Middleport, P. O.), Ohio.
1903	*O'Hearne, John E.*	*345*	*S. M. P., Chicago & Alton R. R.*	*Bloomington, Ill.*
1895	O'Leary, D.		Columbia & Puget Sound R. R.	Seattle, Wash.
1914	O'Neil, J. J.		S. M. P. & M., C. St. P. M. & O. Ry.	St. Paul, Minn.
1912	O'Neil, W. J.		M. M., C. R. I. & P. Ry.	Little Rock, Ark.
1901	Ord, C. R.		M. M., Canadian Pacific Ry.	McAdam Jct., N. B.
1913	Orghidan, Const.		M. I., Roumanian Govt. Rys.	Bucharest, Roumania.
1915	Osborne, H.		Works Mgr., Can. Pac. Ry.	Montreal, Can.
1908	Osborne, H. O.		S. M. P., South Dakota Central Ry.	Sioux Falls, S. D.
1915	Osmer, J. E.		S. M. P., Ann Arbor R. R.	Owosso, Mich.
1907	Oviatt, H. C.		A. M. Supt., N. Y. N. H. & H. R. R.	Taunton, Mass.

JOINED.	NAME.	NO. OF LOCOS.	ROAD.	ADDRESS.
1911	Page, Charles N.		M. M., Lehigh Valley R. R. Co.	Auburn, N. Y.
1910	Painter, J. H.		Supt. Shops, Atlantic Coast Line	Rocky Mount, N. C.
1901	Parish, Le Grand			30 Church st., New York City.
1913	*Park, E. A*	*33*	*S. M. P., Peoria & Pekin Union R. R.*	*Peoria, Ill.*
1912	Parks, G. E.		M. E., Mich. Cent. R. R.	R. 447, Mich. Cent. Term., Detroit, Mich.
1913	Parsons, J. G		S. S., N. Y. C. Lines	Depew, N. Y.
1909	Parra, Manuel		M. M., Mexican Ry	Apazaco, Tlax., Mex.
1912	Paterson, J		Dist. Loco. Supt., Bombay, Baroda & Cent. India Ry., Parel Works	Bombay, India.
1909	Patterson, Robert		M. M., Grand Trunk Ry	Stratford, Ont., Can.
1914	Pattison, R. C		M. E., W. & L. E. R. R.	Brewster, Ohio.
1903	Paul, W. M		M. M., G. H. & H. R. R.	Galveston, Tex.
1891	Paxton, Thos		S. M. P., E. P. & S. W. Ry	El Paso, Tex.
1904	Pearce, J. S		M. M., Norfolk & Western Ry	Portsmouth, Ohio.
1903	Pearsall, D. M		Atlantic Coast Line	Montgomery, Ala.
1914	*Perine, D. M*	*746*	*S. M. P., Penna. R. R*	*New York City.*
1915	Perkinson, T. F		A. M. M., B. & O. R. R	Keyser, W. Va.
1910	Perrine, W. M		M. M., Cent. R. R. of N. J	Jersey City, N. J.
1915	Pervzoff, A. G.		E., Imper. Russian Govt. for the Inspection of Works and M. of W. & C.	Philadelphia, Pa.
1913	Peterescue, Dimitril.		M. E., Roumanian Govt. Rys	Bucharest, Roumania.
1914	Peterson, W. C		M. M., So. Pac. Co	Tucson, Ariz.
1897	Peyton, H. T			
1907	Pfahler, F. P			1737 Willars st., Washington, D. C.
1907	Pfafflin, Louis		M. M., Indianapolis Union Ry	Indianapolis, Ind.
1897	Pflager, H. M		Commonwealth Steel Co	St. Louis, Mo.
1914	Pickard, F. C		M. M., D. L. & W. R. R.	Buffalo, N. Y.
1902	Pilcher, John A		M. E., Norfolk & Western Ry	Roanoke, Va.
1901	Place, F. E		Buda Foundry & Machinery Co	Harvey, Ill.
1900	Plank, P. D			
1903	Platt, J. G		Hunt-Spiller Mfg. Co	348 Dorchester ave., Boston, Mass.
1912	Porter, C. D		A. M. M., Penna. R. R	Pittsburgh, Pa.
1910	Potts, C. H		M. M., Penna. R. R	Renovao, Pa.
1906	Powers, M. J		Denver & Rio Grande	Denver, Colo.
1903	Pratt, Edward W		A. S. M. P., C. & N. W. Ry	Chicago, Ill.
1907	Prendergast, A. P		S. M., T. & P. Ry	Marshall, Tex.
1913	Prendergast, R. Q		S. M. P., Bangor & Aroostook R. R.	Bangor, Me.
1891	Prescott, C. H		M. M., Spokane International Ry	Spokane, Wash.
1905	Preston, Robert		M. M., Canadian Pacific Ry	Winnipeg, Man., Can.
1913	*Purcell, J*	*2108*	*Asst. to V.-P., A. T. & S. F. Ry*	*Chicago, Ill.*
1905	Purdy, Joseph & B		Care O. R. L. Co	Honolulu, Hawaii.
1915	Quattrone, F		T. E. Italian State Rys	17 Ballery Place, N. Y. City.
1888	Quayle, Robt		S. M. P. & M., C. & N. W. Ry	Chicago, Ill.
1895	Quereau, C. H		N. Y. C. R. R	1232 Central Sta., New York, N. Y.
1908	Quigley, Joseph			
1909	Rae, Clark H		A. S. M. P., Louisville & Nashville R. R.	Louisville, Ky.
1911	Ramage, J. C		Supt. Tests., Southern Ry	Alexandria, Va.
1908	Randolph, J. L			
1908	Randolph, L. S			Blacksburg, Va.
1912	Randolph, V. C		M. M., Erie R. R	Avon, N. Y.

JOINED.	NAME.	NO. OF LOCOS.	ROAD.	ADDRESS.
1913	Ralston, J. A		M. E., Union R. R	Pittsburgh, Pa.
1914	Rauch, H. S		G. F., N. Y. C. & H. R. R. R	Avis, Pa.
1912	Raven, Vincent L		C. M. E., North Eastern Ry	Darlington, Eng.
1912	Ray, G. W			
1913	Raymond, P. L		M. P. I., Phila. & Reading Ry	Reading, Pa.
1911	*Reading, R. K*	1410	*S. M. P., Penna. R. R*	Altoona, Pa.
1910	Regan, Frank H		Supt. of Shops, D. L. & W. R. R	Scranton, Pa.
1901	Redding, D. J		M. M., Pittsburgh & Lake Erie R.R.Co	McKee's Rocks, Pa.
1911	Reed, F. C			
1915	Reese, O. P		A. E. M. P., Penna. Co	Pittsburgh, Pa.
1904	Reeves, P. H		M. M., B. & O. S. W. Ry	Chillicothe, Ohio.
1912	Reid, D			Globe, Ariz.
1909	Reid, H. G		M. M., Canadian Pacific Ry	Moose Jaw, Sask., Can.
1902	Reid, W. L		Supt., American Locomotive Co	Schenectady, N. Y.
1883	Renshaw, Wm			Railway Exchange, Chicago, Ill.
1896	Reynolds, O. H		W. Jessep & Son	New York City.
1914	Rhoads, H		M. M., N. O. T. & M. Ry	De Quincy, La.
1889	Rhodes, L. B		S. M., Standard H & V. Co	Richmond, Va.
1911	Rhuark, F. W		M. M., Baltimore & Ohio R. R	Lorain, Ohio.
1909	Riberio, J. Assis		Loco. Supt., Central Ry. of Brazil	Engenho do Dentro Rio Janeiro, Brazil, S. A.
1915	Richards, L. D		M. M., Rock Island Lines	Little Rock, Ark.
1907	Richardson, Louis A		M. S., C. R. I. & P. Ry	Des Moines, Iowa.
1901	Richmond, W. H		M. M., L. S. & I. Ry	Marquette, Mich.
1914	Ricketson, W. E		M. E., C. C. C. & St. L. Ry	Beech Grove, Ind.
1910	Ridgway, Geo		Riverview House	Waterford, Ireland.
1909	*Ridgeway, H. W*	197	*M. M., Colo. & Southern Ry*	*Denver, Colo.*
1907	Rieckmann, Wm. H		A. M. M., Boston & Maine R. R	Mechanicsville, N. Y.
1909	Riegel, S. S		M. E., D. L. & W. R. R	Scranton, Pa.
1915	Riley, G. N		S. M. P., McK. Conn. R. R	Frick Bldg., Pittsburgh, Pa.
1915	Ripley, Chas. T		G. M. I., A. T. & S. F. Ry	Chicago, Ill.
1913	Riley, S. B		G. F., West Md. Ry	Hagerstown, Md.
1913	Roach, J. L		M. M., Ft. W. & D. C. R. R	Childress, Tex.
1909	Rink, Geo. W		M. E., C. R. R. of N. J	Jersey City, N. J.
1912	Robb, G. W		M. M., Grand Trunk Pacific Ry	Winnipeg, Man., Can.
1902	Robb, J. M			6510 Woodlawn ave., Chicago, Ill.
1901	Robb, W. D		S. M. P., Grand Trunk Ry	Montreal, Que., Can.
1909	Roberts, C. F		A. S. M. P., United Rys. of Havana, Havana Cent. Ry	Havana, Cuba.
1901	Roberts, Joseph		M. M., Union Pacific R. R. Co	Kansas City, Kan.
1910	Robertson, D. D		M. M., Lehigh Valley R. R	Buffalo, N. Y.
1915	Robertson, M		D. M. M., G. C. & S. F. Ry	Temple, Tex.
1909	Robinson, W. H		G. M., Bolivia Ry. Co	Antofagasta, Chili.
1906	Roesch, F. P		M. M., El Paso & S. W. System	Box 871, Douglas, Ariz.
1913	Rogers, W. A		M. M., S. P. L. A. & S. L. R. R	Las Vegas, Nev.
1909	Rollings, E. O		M. M., L. & N. R. R	Howell, Ind.
1900	Roope, Thos		S. M. P., C. B. & Q. R. R	Lincoln, Neb.
1896	Rosing, W. H. V		Spec. Engr., St. L. & S. F. Ry	Springfield, Mo.
1912	Ross, Thomas		M. M., T. & N. O. Ry	Toronto, Ont., Can.
1915	Rosser, H. S		S. S., Seaboard Air Line Ry	Jacksonville, Fla.
1895	Royal, C. B			101 Holley ct., Oak Park, Ill.
1907	Rumney, T			Nelson st., Bayside, L. I., N. Y.
1896	Rusch, Peter C		B. R. & P. Ry	Bradford, Pa.
1907	Russell, W. B		Director of Franklin Union, Berkley and Appleton sts., Boston, Mass.	
1892	Ryan, Patrick		M. M., L. & N. R. R. Co	Russellville, Ky.

JOINED.	NAME.	NO. OF LOCOS.	ROAD.	ADDRESS.
1892	Sague, J. E			Cliffdale Farm, Poughkeepsie, N. Y.
1912	Sagstetter, W. H		M. M., Kansas City Southern Ry	Shreveport, La.
1896	Sanderson, R. P. C		Baldwin Locomotive Co	Philadelphia, Pa.
1915	Sandman, A. G		Chief Drafts., M. P. Dept., B. & O. R.R.	Baltimore, Md.
1908	Sasser, E. C		S. M. P., Southern Ry	Washington, D. C.
1905	Schlacks, W. J		McCord & Co	Peoples Gas Bldg., Chicago, Ill.
1904	*Schlafge, William*	1 501	*G. M. S., Erie R. R*	*New York City.*
1911	Schultheiss, R		S. M. P., Guayaquil & Quito Ry	Guayaquil, Ecuador.
1913	Scanland, N. B		M. M., Maryland & Penna. R. R	Baltimore, Md.
1913	Scott, J. H		A. L. S., Southern Rys. of Peru	La Paz, Bolivia.
1901	Seabrook, C. H		S. M., Int. & Grt. Nor. Ry	Palestine, Tex.
1912	Searles, E. J		Shaffer Equip. Co	Pittsburgh, Pa.
1907	Sechrist, T. O		M. M., C. N. O. & T. P. Ry	Somerset, Ky.
1907	Seddon, C. W		S. M. P. & C., D. M. & N. R. R	Proctor, Minn.
1900	Seidel, Geo. W		S. M. P., M. & St. L. R. R	Minneapolis, Minn.
1913	Seeger, J. C		S. S., Lehigh Valley R. R	Sayre, Pa.
1900	Seley, C. A			McCormick Bldg., Chicago, Ill.

1912	Shaffer, C. A		G. T. I., Illinois Central R. R	Chicago, Ill.
1908	Sharp, C. L		G. F., C. R. I. & P. Ry	El Reno, Okla.
1912	Sheafe, J. S			1148 E. 74th st., Chicago, Ill.
1904	*Sheahan, J. F*	86	*S. M. P., A. B. & A. R. R*	*Fitzgerald, Ga.*
1907	Shelaberger, John		M. M., Southern Pacific Co	Bakersfield, Cal.
1910	Shelby, C. K		M. M., Northern Central Ry	Olean, N. Y.
1899	Shepard, L. A		Scullin Gallagher Iron & Steel Co	Munsey Bldg., Washington, D. C.
1903	Shepard, Samuel		M. M., M. St. P. & S. S. M. Ry	Gladstone, Mich.
1912	Shima, Yas		C. M. E., Imperial Govt. Rys	Tokio, Japan.
1904	Shoemaker, H		M. S., Bangor & Aroostook R. R	Derby, Me.
1906	Shreeve, W. J		M. D. & W. R. R	International Falls, Minn.
1915	*Shull, G. F*	47	*M. M., C. C. & O. Ry*	*Erwin, Tenn.*
1883	Sinclair, Angus			114 Liberty st., New York City.
1892	Sinnott, W		M. M., Baltimore & Ohio R. R	58th st., Philadelphia, Pa.
1912	Sisco, G. E		A. E. M. P., Pennsylvania Lines	Columbus, Ohio.
1912	Siverwright, J. S		Asst. Loco. Supt., Cuban Central Rys	Sagua la Grande, Cuba.
1899	Skinner, H. M. C			481 Durfee st., Fall River, Mass.
1894	*Slayton, C. E*	23	*Asst. Supt., St. J. & G. I. R. R*	*St. Joseph, Mo.*
1900	Slayton, F. T		S. M. P., Virginian Ry	Princeton, W. Va.
1909	Small, Fred. F		M. E., Pacific Electric Ry	Los Angeles, Cal.
1908	*Small, J. W*	525	*S. M. P., S. A. L. Ry*	*Portsmouth, Va.*
1914	Small, W. T		M. M., So. Pac. Co	Dunsmuir, Cal.
1909	Smethurst, T		S. M. P. and R. S., Interoceanic Ry	Pueblo, Mex.
1903	Smith, Carl B		M. E., B. & M. R. R	17 Beverly st., Melrose, Mass.
1904	Smith, E. J		M. M., Atlantic Coast Line R. R	Florence, S. C.
1900	Smith, F. J		M. M., Chgo. Gt. West. R. R	Stockton, Ill.
1910	Smith, H. E		Chemist, N. Y. C. R. R	Collinwood, Ohio.
1914	Smith, J. G		Gen. Fore., West. Md. Ry	Hagerstown, Md.
1892	Smith, Jno. L		G. F., P. S. & N. R. R	St. Marys, Pa.
1910	Smith, L. K		A. M. M., Wabash R. R	Moberly, Mo.
1900	Smith, L. L		Westinghouse Machine Co	E. Pittsburgh, Pa.
1914	Smith, M. R		M. M., C. I. & L. R. R	Lafayette, Ind.
1912	*Smith, P. F., Jr*	181	*S. M. P., Penna. R. R. Co. (Cent. Sys.)*	*Toledo, Ohio.*
1899	*Smith, R. D*	395	*S. M. P. and R. S., B. & A. Ry*	*South Station, Boston, Mass.*
1905	*Smith, R. E*	811	*G. S. M. P., Atlantic Coast Line Ry*	*Wilmington, N. C.*
1911	Smith, S. A		D. M. M., B. & M. R. R	E. Somerville, Mass.

JOINED.	NAME.	NO. OF LOCOS.	ROAD.	ADDRESS.
1906	Smock, F. A		M. M., Pennsylvania R. R	Jersey City, N. J.
1911	Snell, E. J		M. M., N. Y. C. & H. R. R. R	Corning, N. Y.
1915	Snyder, W. H		M. M., N. Y. S. & W. R. R	Stroutsburg, Pa.
1911	Spengler, C. H		M. M., Butte, Anaconda & Pac. Ry	Anaconda, Mont.
1907	Sprowl, N. E		S. M. P., Atlantic Coast Line R. R	Rocky Mount, N. C.
1901	Squire, W. C		Consulting Engineer	209 Western Union Bldg., Chicago, Ill.
1909	Staley, H. F		S. M. P., B. C. G. & A. R. R	Boyne City, Mich.
1898	Stansbury, C. M			516 E. 3d st., Roswell, N. M.
1898	Stevenson, C. W		Estrado de Fero Central de Brasil, L. V.	a Divisao, Officianas de Engenho de Rio de Janeiro, Brasil.
1913	Stevens, H. C		M. M., D. & R. G. R. R	Alamosa, Colo.
1906	Stewart, A. F		M. M., Chesapeake & Ohio Ry	Richmond, Va.
1906	Stewart, C. J		M. M., N. Y. N. H. & H. R. R	South Boston, Mass.
1909	Stewart, R. L		M. S., C. R. I. & P. Ry	El Reno, Okla.
1912	Stockton, Jas		M. M., N. O. T. Co	New Orleans, La.
1914	Stone, G. M		M. M., Rock Island Lines	Chickasha, Okla.
1914	Stout, H. E		M. M., Spanish American Iron R. R. & Mines	Felton, Cuba.
1911	Storey, J. W		C. D., Central of Georgia Ry	Savannah, Ga.
1914	Stranahan, J. H		M. M., Dela. & Hudson Co	Watervliet, N. Y.
1912	Strauss, M. H			
1914	Streeter, L. P		A. B. E., Ill. Cent. R. R	Chicago, Ill.
1913	Stroud, C. H			145 Iroquois st., Laurium, Mich.
1907	Stuart, Charles M		M. M., Philadelphia & Reading Ry	Tamaqua, Pa.
1911	Stubbs, F. W		M. E., Chicago Great Western Ry	Oelwein, Iowa.
1910	Stubbs, G. W		M. M., Ocilla So. R. R	Ocilla, Ga.
1890	Studer, A. L		Care McColgan's Hotel	McComb City, Miss.
1901	*Sullivan, J. J*	258	*S. M., N. C. & St. L. Ry*	*Nashville, Tenn.*
1909	Sullivan, T. F		M. M., San Antonio & Aransas Pass Ry	Yoakum, Tex.
1891	Summerskill, T. A		S. M. P., Cent. Vt. Ry	St. Albans, Vt.
1892	Sumner, Eliot		M. M., Northern Central Ry	Baltimore, Md.
1910	Sumner, Eben T		M. M., Boston & Maine R. R	East Cambridge, Mass.
1909	Sweeley, E. H		G. F. L. R., Long Island R. R	Richmond Hill, N. Y.
1909	Sweetman, E. M		M. M., Southern Ry	Spencer, N. C.
1901	Swoyer, H		Mgr. Brooks Works, Amer. Loco. Co	Dunkirk, N. Y.
1908	Symons, J. E		D. M. M., G. C. & S. F. Ry	Cleburne, Tex.
1892	Symons, W. E			Postal Tel. Bldg., Chicago, Ill.
1914	Tate, M. K		Amer. Arch Co	30 Church st., New York City.
1896	Tawse, Robt		S. M. P., D. T. & I. Ry	Jackson, Ohio.
1915	*Taylor, F. T*	184	*S. M. P., Inter. Gt. Nor. Ry*	*Palestine, Tex.*
1901	Taylor, H. D			Milwaukee, Wis.
1905	Taylor, Wm. Marley		M. M., Thornton & Alexandria Ry	Thornton, Ark.
1913	Teaque, A. S		Care of Santa Fe Railroad	Box 775, Winslow, Ariz.
1912	Tegtmeyer, E. F		M. M., C. R. I. & P. Ry	Goodland, Kan.
1905	Temple, C. H		S. M. P., Canadian Pacific Ry. Co	Winnipeg, Man.
1904	Terrell, C. H		S. M. P., Chesapeake & Ohio Ry	Huntington, W. Va.
1911	Thayer, F. C		G. R. F. E., Southern Ry	Atlanta, Ga.
1915	Thibaut, Geo		M. M., Erie R. R	Port Jervis, N. Y.
1891	*Thomas, H. T*	34	*M. M., Detroit & Mackinac R. R*	*East Tawas, Mich.*
1910	*Thomas, I. B*	517	*S. M. P., Pennsylvania R. R*	*Williamsport, Pa.*
1892	*Thomas, J. J., Jr.*	287	*S. M. P., Southern Ry. Co. in Miss., Mobile & Ohio R. R*	*Mobile, Ala.*

JOINED.	NAME.	NO. OF LOCOS.	ROAD.	ADDRESS.
1896	*Thompson, Geo*	*44*	*S. M. P., Denver & Salt Lake R. R.*	*Denver, Colo.*
1902	Thompson, W. O.		S. R. S., N. Y. C. R. R.	Cleveland, Ohio.
1904	Thompson, W. T.		Care of Chas. A. Thompson Estate	227 Hillside Ave., Jamaica, N.Y.
1912	Thomson, H. R.		M. M., Newburg & So. Shore Ry	Cleveland, Ohio.
1910	Thomson, S. G.		S. M. P., Philadelphia & Reading Ry	Reading, Pa.
1902	Thornton, C. J.		M. E., Messrs., Rio Tinto Co., Ltd	Huelva, Spain.
1911	Tierney, H. J.		M. E., Missouri, Kansas & Texas Ry	Denison, Tex.
1909	Tildon, C. F.			1386 "D" st., San Bernardino, Cal.
1901	Tolts, Max		V. P. & G. M., M. & G. R. Ry	St. Paul, Minn.
1903	Todd, A. B.			843 California st., San Francisco, Cal.
1892	Todd, Louis C.		M. M., Boston & Maine R. R.	Charlestown, Mass.
1898	*Tollerton, W. J.*	*1 678*	*G. M. S., C. R. I. & P. Ry*	*Chicago, Ill.*
1904	Tonge, John			18 No. 12th st., Minneapolis, Minn.
1903	*Torrey, F. A.*	*1 742*	*G. S. M. P., C. B. & Q. R. R.*	*Chicago, Ill.*
1896	Tracy, W. L.		A. S. M., Missouri Pacific Ry	St. Louis, Mo.
1908	Tritsch, Chas. M.		S. M. P., Western Maryland R. R.	Hagerstown, Md.
1903	Trumbull, A. G.		M. S., Erie R. R.	Jersey City, N. J.
1914	Trout, W. S.		G. F., West. Md. R. R.	Cumberland, Md.
1914	*Turnbull, R. J.*	*1 194*	*M. S., Mo. Pac. Ry*	*St. Louis, Mo.*
1899	Turner, Amos		M. M., Lehigh Valley R. R. Co	South Easton, Pa.
1890	Turner, Calvin G.			1321 West 8th st., Wilmington, Del.
1906	Turner, John A.		M. M., C. St. P. M. & O. Ry	Spooner, Wis.
1906	Turtle, J. A.		M. M., Union Pacific R. R.	Denver, Colo.
1890	*Turner, L. H.*	*256*	*S. M. P., P. & L. E. R. R.*	*Pittsburgh, Pa.*
1898	Van Alstyne, David		Quigley Furnace & Foundry Co	New York City.
1905	Vanaman, C. D.		M. M., Florida East Coast Ry	St. Augustine, Fla.
1904	Van Buskirk, H. C.		S. M. P., Rock Island Lines	Des Moines, Iowa.
1896	Van Cleve, J. R.		M. M., West. Pac. Ry	Elko, Nev.
1904	Van Doren, G. L.		Supt. Shops, Central R. R. of N. J.	Roselle Park, N. J.
1910	Van Valin, H. D.		Standard Oil Co. (Indiana)	Chicago, Ill.
1891	Vauclain, S. M.		Baldwin Locomotive Works	Philadelphia, Pa.
1898	*Vaughan, H. H.*			*Montreal, Can.*
1892	Vogt, A. S.		M. E., Pennsylvania R. R. Co	Altoona, Pa.
1912	Wade, Evan H.		S. M. P., C. & N. W. Ry	Chicago, Ill.
1904	Wagstaff, Geo.		American Arch Co	30 Church st., New York City.
1905	*Wahlen, John*	*10*	*M. M., Montpelier & Wells River R. R.*	*Montpelier, Vt.*
1904	Walker, H. E.			River Platte House, London, E. C., Eng.
1908	Wall, George L.		M. E., Lima Loco. & Mach. Co	Lima, Ohio.
1908	Wall, H. S.		M. M., A. T. & S. F. Ry	1087 C st., San Bernardino, Cal.
1915	Wallis, J. T.		G. S. M. P., Penna. Railroad	Altoona, Pa.
1888	Wallis, Philip			Hotel Roanoke, Roanoke, Va.
1910	Walsh, F. A.		M. M., Marshall & East. Texas Ry	Marshall, Tex.
1915	Walsh, F. J.		Galena Signal Oil Company	319 Railway Exchange, Chicago.
1900	*Walsh, F. O.*	*78*	*S. M. P., Georgia R. R.*	*Augusta, Ga.*
1910	Walsh, Geo. B.		G. F., N. Y. C. R. R.	Corning, N. Y.
1903	Walsh, J. F.		M. E., C. & O. Ry	Richmond, Va.
1908	Walsh, W. F.		Galena Signal Oil Company	319 Railway Exchange, Chicago.
1914	Wanamaker, H.		S. S., N. Y. C. R. R.	W. Albany, N. Y.
1908	*Warnock, H. R.*	*263*	*West. Md. Ry*	*Hagerstown, Md.*
1882	Warren, W. B.			1619 Pennsylvania ave., St. Louis, Mo.
1910	Warthen, H. J.		M. M., Washington Southern Ry	Alexandria, Va.

JOINED.	NAME.	NO. OF LOCOS.	ROAD.	ADDRESS.
1909	**Warthen, J. O.**		M. M., Danville & Western Ry. Co.	Danville, Va.
1903	**Waters, J. J**		S. M. P., Pere Marquette R. R.	Grand Rapids, Mich.
1906	**Watkins, W. H**			1832 So. Wilmington st., Memphis, Tenn.
1914	**Watkins, G. H**		A. E. M. P., Penna. R. R. (W. P. D.)	Pittsburg, Pa.
1908	**Watson, R. B**		Engr. of Tests, Erie R. R.	Meadville, Pa.
1902	**Watson, Samuel**		D. S. M. P., N. Y. C. R. R.	Avis, Pa.
1904	**Watters, J. H**			
1883	**Watts, A. H**			Van Wert, Ohio.
1914	**Webb, E. R.**		M. M., Mich. Cent. R. R.	St. Thomas, Ont., Can.
1915	**Webster, H. D**		M. E., B. & L. E. R. R.	Greenville, Pa.
1906	**Wells, M. E**		A. M. M., Wheeling & Lake Erie R. R.	Brewster, Ohio.
1909	**Weitzel, H.**		A. S. D., Ariz. East. R. R.	Phœnix, Ariz.
1911	**Werst, C. W**		Baldwin Locomotive Wks	526 No. 26th St., Philadelphia.
1915	**Wheatley, B. L.**		M. M., Rock Island Lines	Ft. Worth, Tex.
1885	**White, A. M**		American Locomotive Co.	Paterson, N. H.
1915	**Whiteley, G**		A. S. M. P., Can. Pac. Railway	Montreal, Canada.
1914	**Whitsel, N. B**		G. F., C. & W. I. R. R.	Chicago, Ill.
1898	**Whyte, F. M**		Care Hutchins Car Roofing Co.	14 Benedict ave., Tarrytown, N. Y.
1912	**Wieseckel, G. F**		M. M., West. Md. R. R.	Baltimore, Md.
1899	**Wiest, E. N.**		Dist. Inspr. of Loco. Boiler	Little Rock, Ark.
1894	**Wiggin, C. H**		S. M. P., Boston & Maine R. R. Co.	Boston, Mass.
1878	**Wightman, D. A**			Warren, R. I.
1891	**Wilcox, W. J.**		M. M., Las Vegas & Tonopah R. R.	Las Vegas, Nev.
1901	***Wildin, G. W***	1 269	*Mech. Supt., N. Y. N. H. & H. R. R.*	*New Haven, Conn.*
1912	**Willans, Geo**			22 Heathville Road, Gloucester, Eng.
1896	**Williams, Alfred**		Care Companbia Paulista, Jundiohy, Estado de Sao Paulo, Brasil, S. A.	
1905	**Williams, C. R.**		Corning Machine Co.	Corning, N. Y.
1891	**Williams, E. A.**			259 Ridgewood ave., Glen Ridge, N. J.
1910	**Williams, E. V**			
1903	**Williams, F. W**			605 Washington ave., So., Minneapolis, Minn.
1909	**Williams, W. H**		M. M., B. R. & P. R. R.	Salamanca, N. Y.
1905	**Willins, Gustav, Jr**		Robinson, Cary & Sands Co.	St. Paul, Minn.
1905	**Wilson, Charles**		M. M., Lehigh Valley R. R.	Wilkesbarre, Pa.
1906	**Wilson, David H., Jr.**		Elec. Engr., Erie R. R.	Meadville, Pa.
1887	**Wilson, Geo. F**			1231 Madison ave., New York City.
1912	**Wilson, G. M**			
1914	**Wilson, T., Jr.**		M. M., Ga. Coast & Piedmont R. R.	Crescent, Ga.
1901	**Wilson, W. H**		Asst. to 3d V.-P., Nor. Pac. Ry	St. Paul, Minn.
1915	**Wilson, W. M**		M. M., Rock Island Lines	Dalhart, Tex.
1913	**Winterrowd, W. H.**		M. E., Can. Pac. Ry	Montreal, Que., Can.
1900	**Wirt, G**		M. M., C. C. C. & St. L. Ry	Delaware, Ohio.
1914	**Withrow, P. C**		M. E., D. & R. G. R. R.	Denver, Colo.
1914	**Woodard, C**		M. M., K. C. M. & O. Ry	San Angelo, Tex.
1906	**Woodbridge, H. C.**		Spec. Repr. G. M., B. R. & P. Ry	Rochester, N. Y.
1910	**Woodcock, C. A**		M. M., Caquas Tramway	San Juan, Porto Rico.
1915	***Woodhouse, W. E***	2 267	*C. M. E., Can. Pac. Ry*	*Montreal, Que., Can.*
1903	**Woodruff, S. N.**		M. M., M. St. P. & S. S. M. Ry.	Enderlin, N. D.
1915	**Woods, J. E**		G. F., Staten Island Lines, B. & O. R. R.	Clifton, Staten Island, N. Y.
1913	**Wright, O. C.**		A. E. M. P., Penna. Lines, West	Ft. Wayne, Ind.
1901	**Wright, R. V**			192 No. Walnut st., East Orange, N. J.
1907	**Wyman, R. L.**		M. M., Lehigh & New England R. R.	Pen Argyl, Pa.
1908	**Yeager, Thomas**		M. M., Illinois Southern Ry	Sparta, Ill.
1903	**Yergens, W. F**		M. M., Erie R. R. Co.	Huntington, Ind.

JOINED.	NAME.	NO. OF LOCOS.	ROAD.	ADDRESS.
1906	*Yohn, A. E*	22	*M. M., H. & B. T. M. R. R*	*Saxton, Pa.*
1899	York, F. Colin		Loco. Supt., Buenos Aires & Pacific Ry.	Junin Provincia, Buenos Aires, Arg. Rep., S. A.
1902	Young, C. B		M. E., C. B. & Q. R. R	Chicago, Ill.
1908	Young, Charles D		E. T., Pennsylvania Lines, West	Altoona, Pa.
1914	Younger, T. W		S. M. P., So. Pac. Co	Sacramento, Cal.
1911	Zimmerman, A			Ft. Wayne, Ind.
1912	Zeleny, Frank		Engr. Tests, C. B. & Q. R. R	Aurora, Ill.

ASSOCIATE MEMBERS.

JOINED.	NAME.	ADDRESS.
1911	Averill, E. A	Amer. Engineer & R. R. Journal, New York City.
1898	Basford, G. M	Jos. T. Ryerson & Son, 30 Church St., New York City.
1898	Bates, E. C	Lock Box 1544, Boston, Mass.
1907	Bell, J. Snowden	P. O. Box 629, New York City.
1911	Endsley, L. E	Professor: University of Pittsburgh, Pittsburgh, Pa.
1896	Fowler, Geo. L	83 Fulton st., New York City.
1907	Fry, Lawford H	Standard Steel Works, Burnham, Pa.
1895	Goss, W. F. M	University of Illinois, Urbana, Ill.
1889	Hill, John A	505 Pearl st., New York City.
1899	Kneass, Strickland L	Wm. Sellers Co., Ltd., Philadelphia, Pa.
1901	Lane, F. W	
1904	Lanza, Gaetano	Philadelphia, Pa.
1901	Player, John	American Loco. Co., Brooks Works, Dunkirk, N. Y.
1889	Pomeroy, L. R	50 Church st., New York City.
1909	Schmidt, E. C	University of Illinois, Urbana, Ill.
1899	Smart, R. A	Georgiana, Fla.
1882	Smith, W. A	Manhattan Bldg., Chicago, Ill.
1899	Street, Clement F	30 Church st., New York City.
1903	Taylor, Jos. W	1112 Karpen Bldg., Chicago, Ill.
1914	Wood, A. J	Penna. State College, State College, Pa.

HONORARY MEMBERS

JOINED.	NAME.		ADDRESS
1892	Allen, G. S		Tamaqua, Pa.
1892	Bechhold, H. G		Cleveland, Ohio
1885	Becker, Andrew		New Decatur, Ala.
1894	Branch, Geo. E		298 Prospect pl., Brooklyn, N. Y
1879	Briggs, R. H		216 So. Laudendale st., Memphis, Tenn
1891	Brown, W. A		610 Brooks st., Charleston, W. Va.
1879	Cooke, Allen		Danville, Ill.
1879	Cooper, H. L		Chesterton, Ind.
1876	Cory, Chas. H		Lima, Ohio.
1895	Coster, E. L		Broad Exchange Bldg., 25 Broad st., New York City.
1893	Davis, E. E		Newmarket, N. H.
1881	Eastman, A. G		Sutton, Que.
1885	Galloway, A		Chief of Police, Los Angeles, Cal.
1887	Garstang, Wm		2066 No. Delaware ave., Indianapolis, Ind.
1883	Gilmore, W. L		Elkhart, Ind.
1887	Hill, J. W		Peoria, Ill.
1896	Hill, Rufus		Moorestown, Burlington Co., N. J.
1874	Jeffrey, E. T	Denver & Rio Grande	Denver, Colo.
1893	McElvaney, C. T		Denison, Tex.
1878	Maglenn, Jas	Seaboard Air Line	Raleigh, N. C.
1888	Medway, John		146 No. Harvard blvd., Los Angeles, Cal.
1871	Miles, F. B	Bement & Miles	Philadelphia, Pa.
1885	Millen, Thos		105 W. 51st st., New York City.
1885	Paxson, L. B		111 West Liberty st., Lancaster, Pa.
1874	Place, T. W		Waterloo, Iowa.
1892	Rettew, C. E		Carbondale, Pa.
1887	Rhodes, Godfrey W		Westbaugh, Pontefract, Yorkshire, England
1870	Robinson, W. A		Hamilton, Ont.
1885	Sedgwick, E. V		Franklin, Pa.
1869	Sellers, Morris		Western Union Bldg., Chicago, Ill.
1869	Setchel, J. H		Cuba, N. Y.
1891	Sheer, J. M		514 7th st., East St. Louis, Ill.
1888	Sheppard, F. L	Pennsylvania	Altoona, Pa.
1869	Smith, W. T		Covington, Ky.
1868	Sprague, H. N		313 Lincoln ave., Millvale, Allegheny Co., Pa.
1875	Strode, Jas		Elmira, N. Y.
1883	Sullivan, A. W		Chicago, Ill.
1883	Tandy, H		Kingston, Ont., Can.
1883	Thomas, W. H		4230 Spruce st., Minneapolis, Minn.
1870	Towne, H. A		54 S. 3d st., Minneapolis, Minn.
1886	Turner, J. S		24 Broad st., New York City.
1883	Twombley, F. M		30 Sedgwick st., Jamaica Plains, N.Y.
1892	Waitt, A. M		165 Broadway, New York City.
1896	Walton, E. A		611 Central st., Franklin, Mass.
1886	Weisgerber, E. L	Baltimore & Ohio R. R.	Baltimore, Md.
1874	Walsh, Thos		Howell, Ind.

PROCEEDINGS

OF THE

Forty-Eighth Annual Convention

OF THE

American Railway Master Mechanics' Association

HELD AT

The Greek Temple, Young's Million Dollar Pier

Atlantic City, New Jersey, June 9, 10 and 11, 1915

WEDNESDAY SESSION, June 9, 1915.

The President of the Association, Mr. F. F. Gaines, Superintendent of Motive Power, Central of Georgia Railway, called the meeting to order at 9:30 o'clock A.M.

THE PRESIDENT: The time has now arrived for opening this convention. I will ask the officers of the Master Car Builders' Association to come forward and take seats upon the platform, also the officers of the American Railway Master Mechanics' Association as well as the past presidents of both Associations. The opening prayer will be made by the Rev. Doctor Newton D. Cadwell, Pastor of the Olivet Presbyterian Church of Atlantic City, and I will ask you all to rise while the prayer is being offered.

Doctor Cadwell then invoked the Divine Blessing.

THE PRESIDENT: I am going to crave your indulgence this morning. I have had an attack of rheumatism, and I am not feeling very well, and have delegated to the Secretary the task of

reading the Address of the President, and I hope you will pardon me for it.

ADDRESS OF THE PRESIDENT.

Ladies and Gentlemen, Officers and Members of the American Railway Master Mechanics' Association:

As presiding officer, I welcome you to the Forty-eighth Annual Convention of the Association, and also call your attention to the fact that it has arrived at mature years and will enjoy a semi-centennial in 1917.

It gives me great pleasure to see so many old friends; and I anticipate both pleasure and instruction in gathering with them. However pleasant this may be, we must not overlook the fact that Father Time with his scythe has been busy during the past year, and nineteen of our former associates have completed their labors and gone to their final rest. These are:

ACTIVE MEMBERS.— C. J. McMasters, W. H. Traver, E. B. Gilbert, C. J. Drury, T. E. Adams, A. Stewart, J. P. McCuen, B. B. Cargo, E. A. Miller, A. B. Adams, P. P. Mirtz, E. T. White, Wm. McIntosh, M. E. Sherwood; W. S. Morris.

HONORARY MEMBERS.— John Player, J. M. Foss, J. I. Kinsey, C. A. Thompson.

In looking over the developments of the past year, I do not recall any radical departure in locomotive design. The Erie triplex locomotive was in existence previous to our last convention, this being the most radical innovation in some time. Further than this, and the 2-10-2 type of locomotive, and refinements of existing types, the situation seems to be nearly the same as it was a year ago. There have been, however, developments along other lines which I recommend to you for the most serious consideration.

I will admit that personally I have been somewhat against the idea of one mechanical railroad association heretofore, believing that there was sufficient work and a broad enough field for the existence of the present organizations. However, I think that the time has now come when we should have, under whatever title we may choose to call it, one organization only, divided into such sections as may be found advisable. We now have the Master Mechanics' Association, the Master Car Builders' Association, the Traveling Engineers' Association, the General Foremen's Association, the Association of Railway Electrical Engineers, the Master Blacksmiths' Association, the Master Boilermakers' Association, the Master Painters' Association, and several others. Most of the members of these associations come under the jurisdiction of the mechanical department of a railroad. It would seem to me not only advisable, but very desirable, that some such new association should be formed and take over to a certain extent control of all the others. They need not necessarily

meet at the same time; in fact, I think it would be better to spread the meetings out as at present, but the Executive Committee of the supreme association should pass upon the work of these minor associations.

Heretofore the great argument for consolidation has been the saving of time, and I will admit frankly that my objection to consolidation has previously been on the basis that little could be done along this line; however, whether time can be saved or not seems to me a minor consideration and one that can be determined later. It is rather a question of having one recognized supreme authority on all mechanical matters pertaining to railroad work, which will be the recognized authority.

Until very recently the Master Mechanics' Association has been more of an educational character, with very few standards and very few specifications. This situation is now, of course, being changed, but I wish most urgently to call your attention to the advisability of having standards for such things as are possible to standardize in the way of methods, and also specifications for all classes of material used in locomotive work. I realize that our standing committee has done some very valuable work, but I do not think we have nearly completed the task. We should be in a position at any time to say that such and such is our standard practice; or, that we have a specification for such material.

I would also suggest to the Committee on Specifications that in drawing up specifications for material they be not too rigid in their requirements; in other words, we want to obtain a fair grade of material under such specifications, but we do not want the specifications of such a nature as to involve a greatly increased cost, which would have the effect of a majority of the railroads not using them.

After we have gone further into the matter in the way of standards and specifications, a committee should eventually be appointed to confer with the American Railway Association; possibly the Committee now in existence on Relations between Railways and Legislation should try to get the American Railway Association to lend their efforts, as far as possible, toward urging the railroads to adopt such standards and specifications as the Master Mechanics' Association, or its successor, may produce.

There have arisen during the past year several reasons for my advocating this procedure, and I trust that the incoming Executive Committee will give the subject thorough consideration.

I have several times from the floor called attention to the committees not issuing their reports until just a few days before the opening of the convention. It would seem that it is exceedingly important that the committees get to work early in the year and have their reports in the hands of the Secretary in time, so that they may be published and distributed at least two weeks before the opening of the convention. Many times it would add to the value of the proceedings and the information of the members were these reports available a sufficient length of time to allow of gathering data and investigating practices, so as to be able to discuss

them intelligently and, perhaps, produce further information. I think this is a very live subject and one that I would recommend for the proper handling by the incoming Executive Committee.

Another matter which would add very largely to the value of our proceedings and the amount of information obtained, is a more thorough discussion of the papers. It has been my observation that the discussion is largely confined to a very few members. This should not be so. Oftentimes a member may have information that would be very valuable to the Association, but for some reason or other does not take part in the discussion. I hope that all of you will feel free to talk on any of the subjects under discussion, especially if you have information that is valuable and has not been brought out in the committee's report.

Another matter that has occurred to me as being worthy of consideration is the greater use on the various committees of associate and honorary members. Many of these have had an excellent technical training, are familiar with committee work and have a greater proportion of time possibly at their disposal than men actually in railroad service. It has been suggested to me by one such member that he would be only too glad to work on any committee, help them get their reports in shape and lined up in such form as to be readily investigated and in the best form for discussion. I think we have rather overlooked in the past the utilization of this feature and the value it might be to us.

Another idea I would like to suggest to the incoming Executive Committee is the form in which reports are prepared for the Association. Being a member of a large number of technical societies, in the course of the year I read a great many reports and there is a vast difference between the poorest and the best in the manner of getting them up. It has been suggested that all reports should be indexed on the margin for ready reference, that the logical handling of the subject be followed through consecutively, and that the report, in general, be made as clear and concise as possible.

We have now, to a greater or less extent, adopted the principle of representative membership in the Master Mechanics' Association. This should be further encouraged, and those roads which have not taken out representative membership should be urged to do so, as there is no good reason why every railroad of any consequence should not recognize its obligations to make common cause for the common good and unite to consummate the objects for which the Association exists, until we have practically a complete representative membership, the same as in the Master Car Builders' Association. In view of such a condition it would, therefore, be very unfortunate if this Association should neglect its opportunities and fail to keep at least abreast of the best opinions on all subjects relating to the avowed purposes of the Association.

It would seem from reports made that we are not giving thorough enough training to our inspectors who look after the Federal Boiler Law

and Safety Appliances, and other Interstate Commerce orders, or rulings, as to construction and maintenance of equipment.

It has been recommended that the railroads pay more attention to the educating of road foremen of engines, enginemen and firemen, and give a more thorough examination for firemen before promotion; this in order to get the best results from the various complicated devices we are now placing on our modern locomotives to obtain greater efficiency and economy.

It is also suggested that the University of Illinois has an elaborate testing plant, large enough and of sufficient capacity to take the heaviest locomotive that is built, and the matter of testing locomotives and all modern appliances that are being brought out, such as brick arches, superheaters, valve gears, fire boxes, boilers, etc., be given an elaborate test in their testing plant and the results furnished the members of the Association, the railroads to bear the expense of the test in proportion to the number of engines owned. A test under such conditions would be cheaper to make than if actual road tests were made by any single road, and on account of the locomotives being under cover and not subjected to the variations of temperature, or wind or rain, conditions would practically be uniform for all tests.

During the past year a company has been formed, an engine has been equipped, and an experiment made in the use of powdered fuel. This would seem to be a very live and important subject, and one which should be thoroughly investigated and handled during the next year. The use of powdered fuel, from what little I know of it, would allow the using of lower grades of fuel, slack, etc. It would also give a more even temperature in the fire box, a more even steam pressure, and on large engines so lighten the fireman's work.

Another experiment which has been in progress has been the use of induced draft instead of the present method of using the exhaust for this purpose. This would, also, seem worthy of investigation, as with induced draft the amount of power required would be very small in proportion to the amount gained by cutting down the back pressure of the engine itself on account of being able to use a free exhaust. It is probable that a considerable percentage of horse-power can be added to the locomotive unit for properly designed and sufficiently reliable induced-draft apparatus which will be reasonably free from mechanical failures.

Another suggestion is that consideration be given to the developing and refining of our present types of locomotives on economic lines rather than size or weight solely. The tendency for the past few years seems to have been simply to increase the weight and size, together with power, of our locomotives, without developing to the fullest extent the economic features. It has been observed that the European locomotives, although much lighter than the American locomotives, are much more efficient both as to fuel economy and hauling capacity. From this it would appear

that we have gone ahead building large engines and strengthening weak parts which may have developed, without a great deal of consideration as to the cause of such failures and their proper rectifications.

Another fact that I would like to bring to your attention as being worthy of consideration is that this Association discusses engineering questions fairly well, also questions of locomotive practice; however, they do not go very deep in the discussion of whether investment in either equipment or appliances brings returns on the investment. Do we investigate sufficiently the question of what becomes of the dollar that we spend for these items? Very little is heard concerning cost. Also, it might be well to give consideration to cost of doing various standard classes of work in different shops, so that those of us who are working inefficiently may see just where the leaks are and make the necessary investigation to reduce the expense. Every member of this Association should put himself in the attitude of a business man toward a dollar. As an instance of what I mean in this respect, it would seem to be a possibility that the mechanical men should, and could, put themselves in position to do what the students of the Massachusetts Institution of Technology did in the way of studying the question of miscellaneous freight handling in Boston warehouses, recently described before the New York Railroad Club.

As items that would be of interest to all of us, I suggest a partial list for your consideration:

Cost of small tools and supplies.

Cost of power in power houses.

Comparative costs and results of Thermit, acetylene and electric welding.

Cost of fluework.

Cost of turning power.

Cost of staybolt renewals.

Cost of spring repairs.

Cost of turning driving wheels.

Cost of fitting up driving boxes, shoes and wedges.

These are only a few of the many things around a shop that are going on every day, all of which perhaps are capable of some improvement. If figures could be had as a basis, we would be working more intelligently toward reduced cost.

Do we know when a new engine is put in service, of a new type, whether its increased weight, capacity and cost are justified? Do we follow up this matter and obtain sufficient data to justify our expenditures? Do we know when a new and improved machine tool is purchased and placed in the shop whether or not the cost of same is justified by the output?

The theoretical advantages of the superheater are well known, the practical saving in cost that can be accomplished is well known, but do we know that we are getting anything like this in every-day service?

Do we keep behind our roundhouse foremen to see that flues are

cleaned, superheater surfaces clean, joints tight, and that the proper handling for best results on the road is being carried out? If we do make these investigations, do we keep the operating department informed of them? Do we keep them informed as to results of improved devices and designs? Do we give information as to costs to subordinates in correct form so that they may analyze the results and endeavor to make reductions?

In closing my few brief remarks, I would like to extend my sincere and grateful thanks to the various officials and members of the Executive Committee, and also several of our members who have made suggestions which I have incorporated as far as possible in the foregoing.

THE PRESIDENT: There will be an intermission now of about fifteen minutes for those who do not care to attend the meeting, to leave, and I would like to ask those who stay to come up front and gather together. I would also like to ask those who are members of committees to associate themselves together so that they can communicate with each other should necessity require.

During this and succeeding sessions the following members registered:

Akans, Geo.
Aldcorn, Thos.
Allen, C. W.
Allen, G. S.
Allison, W. L.
Anderson, J. A.
Andrus, C. H.
Anthony, F. S.
Appler, A. B.
Arden, D. D.
Arp, W. C.
Arter, W. D.
Averill, E. A.
Ayers, A. R.

Babcock, W. G.
Baker, Geo. H.
Barnum, M. K.
Barrett, C. D.
Barry, Frank J.
Barton, T. F.
Basford, Geo. M.
Bawden, Wm.
Beamer, Jas. A.
Bennett, W. H.
Bentley, H. T.
Best, W. N.
Bingamon, C. A.
Black, W. G.
Blunt, Jas. G.
Booth, J. K.
Bosworth, Wm. M.
Boulineau, W. W.
Bowers, O.
Bowles, C. K.
Boyden, J. A.
Boyden, N. N.
Brangs, P. H.
Brazier, F. W.
Brennan, E. J.
Brewer, J. W.
Breyer, J. S.
Brown, H. M.
Brown, M. G.
Burns, T. J.
Burton, T. D.
Butler, F. A.
Butler, W. S.
Bussing, G. H.
Byron, A. W.

Caracristi, V. Z.
Carey, J. J.
Carroll, J. T.
Carroll, W. P.
Cassady, J. A.
Chamberlain, E.
Chambers, C. E.
Chidley, Jos.
Clark, F. H.
Coddington, H. W.
Cole, F. J.
Combs, W. B.
Conners, Jas. J.
Conniff, P.
Cooper, F. R.
Cooper, F. T.
Cox, Millard F.
Crandall, W. J.
Crawford, C. H.
Crawford, D. F.
Cromwell, O. C.
Crosby, R. M.
Cross, C. W.

Daley, W. W.

Darlow, A. M.
Davey, Thos. S.
Davis, J. E.
Davis, J. H.
Davis, W. P.
Dawson, L. L.
Deaner, Chas. F.
Deeter, D. H.
Demarest, T. W.
Depue, G. T.
Dillon, S. J.
Dolan, S. M.
Dooley, W. H.
Duffey, G. J.
Dunham, W. E.
Durham, H. P.

Eliot, Sumner
Elmer, Wm.
Elmes, E. E.
Emerson, G. H.
Endsley, L. E.
Ewald, Wm.
Ettenger, R. L.
Ewing, J. J.

Ferguson, L. B.
Ferry, F. C.
Fetner, W. H.
Finegan, L. E.
FitzSimmons, E. S.
Flanagan, M.
Flavin, J. T.
Flory, B. P.
Flynn, W. H.
Fogg, J. W.
Fowler, Geo. L.
Franey, M. D.
Freeman, L. D.
Frice, A. J.
Fry, L. H.
Fuller, C. E.

Gaines, F. F.
Gallagher, G. A.
Galloway, A. K.
Gardner, G. C.
Gardner, Henry
Gaspar, Chas. L.
Gelhausen, F. R.
Gibbins, E. F.
Gibbs, J. W.
Giles, C. F.
Gill, C. A.
Gillespie, H. C.
Gillis, H. A.
Gilmour, Geo.
Glass, J. C.
Gordon, H. D.
Goodrich, H.
Goodwin, G. S.
Gould, J. R.
Gray, G. M.
Graburn, Al.
Gray, B. H.
Greenwood, H. F.
Griffith, W. S.

Haig, M. H.
Hamilton, Tabor
Hammett, P. M.
Harris, C. M.
Harris, H. Y.
Harrington, H. H.
Hartman, W. J.
Hassett, M. W.
Haug, Harry
Hayes, W. C.
Henderson, G. R.
Henry, W. C. A.
Hess, Geo. F.
Highleyman, J. W.
Hildreth, F. E.
Hill, J. F.
Hill, W. H.
Hill, Rufus
Hogan, C. H.
Hoke, H. A.
Hunter, H. S.
Hyndman, F. T.

Irvin, I. B.

Jackson, O. S.
James, Chas.
Jaynes, R. T.
Jones, I. B.

Kaderly, W. F.
Kalbaugh, I. N.
Kantmann, A. G.
Kapp, W. F.
Kearney, A.
Keiser, C. B.
Kendig, R. B.
Kendrich, J. P.
Kellogg, W. L.
Kells, W. A.
Kelly, J. P.
Kiesel, W. F.
Kinney, M. A.
Kinney, W. H.
Kirkpatrick, Jas.
Kneass, Strickland
Knight, H. R.
Kuhn, W. T.

Laizure, L. H.
Langton, Geo. H.
Lanza, G.
Laux, J. P.
Leach, W. B.
Lewis, W. H.
Lillie, G. W.
Little, J. C.
Lovell, Alfred

MacBain, D. R.
Macbeth, H. A.
Machesney, A. G.
McAmis, W. H.
McBride, B. M.
McCarthy, M. J.
McFarland, H. B.
McGoff, J. H.
McGuire, J. J.
McManamy, John
McNulty, F. M.
McQuillen, J. E.

McRae, J. A.
Mackenzie, John
Maher, P.
Manchester, A. E.
Manchester, H. C.
Manning, J. H.
Mannion, T. D.
Marriott, J. F.
Marsh, F. E.
Mauk, E. L.
Maver, A. A.
Maxfield, H. H.
May, H. C.
Meade, P. J.
Mechling, J. E.
Meister, C. L.
Meredith, H. P.
Miller, Geo. A.
Miller, J. B.
Miller, S. W.
Miller, T. E.
Miller, W. J.
Milliken, Jas.
Minshull, P. H.
Moll, George
Monfee, A. J.
Montgomery, Chas.
Montgomery, Hugh
Montgomery, Wm.
Moore, B. R.
Moseley, W. S.
Moses, F. K.
Muhlfield, J. E.
Mullinix, S. W.
Murray, E. A.
Murray, F. H.
Murrian, W. S.

O'Brien, Wm. J.
Oviatt, H. C.

Painter, J. H.
Parish, LeGrand
Parks, G. E.
Parsons, J. G.
Patterson, Robt.
Pattison, R. C.
Pearce, J. S.
Perine, W. M.
Perrine, W. M.
Pilcher, J. A.
Pickard, F. C.
Pomeroy, L. R.
Porter, C. D.
Potts, C. H.
Pfafflin, Louis
Pfahler, F. P.
Pratt, E. W.
Pratt, J. G.
Prendergast, A. P.
Purcell, J. A.

Quereau, C. H.

Rae, C. H.
Randolph, V. C.
Ralston, J. A.
Ramage, J. C.
Rauch, H. S.
Raymond, P. L.
Reagan, F. H.
Redding, D. J.
Reynolds, L. H.
Rhodes, L. B.
Rhuark, F. W.
Richardson, L. A.
Ricketson, W. E.
Rieckman, W. H.
Riegel, S. S.
Riley, Geo. N.
Riley, S. B.
Rink, Geo. W.
Ripley, C. T.
Robinson, M.
Rosing, W. H. V.
Rummey, T.
Rusling, W. J.

Sandman, A. G.
Scanland, N. B.
Schlafge, Wm.
Seley, C. A.
Sheafe, J. S.
Sheahan, J. F.
Shelby, C. K.
Shepard, L. A.
Shoemaker, H.
Shull, G. F.
Sinclair, Angus
Sinnott, Wm.
Slayton, C. E.
Slayton, F. T.
Small, J. W.
Smock, F. A.
Smith, C. B.
Smith, H. E.
Smith, J. L.
Smith, M. R.
Smith, P. F.
Smith, R. D.
Smith, R. E.
Smith, W. A.
Snell, E. J.
Snyder, W. H.
Sprowl, N. E.
Stewart, A. F.
Stewart, R. L.
Stocks, W. H.
Stockton, Jas.
Stranahan, J. H.
Strauss, M. H.
Street, C. F.
Streeter, L. B.
Stuart, Chas. M.
Stubbs, F. W.
Stubbs, G. W.
Sullivan, J. J.
Sweeley, E. H.
Sweetman, E. M.
Symons, J. E.
Symons, W. E.

Taylor, Jos. W.
Terrell, C. H.
Thibaut, Geo.
Thomas, I. B.
Thompson, W. O.
Thomson, H. R.
Todd, L. C.

Tollerton, W. J.	Walsh, F. O.	Wieseckel, G. F.
Trout, W. S.	Walsh, J. F.	Wiggins, C. H.
Trumbull, A. G.	Wanamaker, H.	Wildin, G. W.
Turnbull, R. J.	Warnock, H. R.	Williams, W. H.
Turner, Amos	Warthen, J. O.	Woods, J. E.
	Waters, J. J.	Wright, O. C.
Van Doren, C. L.	Watkins, G. H.	Wright, R. V.
	Watkins, W. H.	Wyman, R. L.
Wagstaff, Geo.	Watson, R. B.	
Wahlen, J. M.	Webster, H. D.	
Wall, Geo. L.	Werst, C. W.	Young, C. B.
Wallis, J. T.	Whyte, F. H.	Young, C. D.

THE PRESIDENT: The next order of business on the program is the approval of the minutes of the last meeting. I would suggest as they have already been printed and put in shape that it is in order that they be approved as printed.

MR. W. E. DUNHAM (C. & N. W. Ry.): I so move you, Mr. President.

Motion seconded and carried.

THE PRESIDENT: The next order of business will be the Secretary and Treasurer's report.

The Secretary presented his annual report as follows:

SECRETARY'S REPORT.

To the President and Executive Committee of the American Railway Master Mechanics' Association:

In accordance with our usual custom at the annual convention, I append herewith statements, showing the membership of the Association and receipts and expenditures during the year just closed.

ACTIVE MEMBERSHIP.

Membership, June, 1915		979
Deaths	15	
Resignations	11	
Dropped, non-payment and mail returned	37	
Transferred to Honorary Membership	3	
Transferred to Representative	89	
		155
		824
New members during the year	68	
Reinstated	5	
		73
Total		897

REPRESENTATIVE MEMBERSHIP.

Membership, June, 1914		000
Transferred from Active Membership	89	
New members	8	
		97
		97
Dropped, account of successor appointed	1	
Dead	1	
		2
Total		95

ASSOCIATE MEMBERSHIP.

Membership June 1914	19

HONORARY MEMBERSHIP.

Membership, June, 1914	48
Dead	4
	44
Elected, 1914 convention	3
Total	47

TOTAL MEMBERSHIP.

Active	897
Representative	95
Associate	19
Honorary	47
Total membership, June, 1915	1 058

The following deaths have been recorded: T. E. Adams, P. P. Mirtz, E. T. White, C. J. McMasters, E. A. Miller, C. J. Drury, E. B. Gilbert, W. H. Traver, A. Stewart, J. P. McCuen, B. B. Cargo, A. B. Adams, Wm. McIntosh, W. S. Morris and C. Phillips, Active Members; J. M. Foss, J. I. Kinsey, C. A. Thompson and John Player, Honorary Members; E. A. Miller, Representative Member.

It is suggested that committees be named to prepare obituaries for incorporation in the report of the Proceedings.

RECEIPTS.

To dues collected from members	$ 7,557.16
" sale of Proceedings	1,875.50
" sale of Headlight Report	710.25
" Ryerson Scholarship	600.00
" interest	14.33
Total	$10,757.24

EXPENSES.

Paid exchange	$ 16.85
" expenses, convention, 1914	315.62
" expenses committees	119.42
" express	10.12
" office supplies and expenses	141.93
" office rent	525.00
" premium on bond, Secretary	5.00
" printing	6,394.95
" reporting convention, 1914	184.15
" salary, Secretary	1,500.00
" office assistants	432.93
" stamps	230.97
" Ryerson Scholarship	500.00
" zinc cuts	289.30
" tracings and blue-prints	91.00
	$10,757.24

LIST OF DUES COLLECTED FROM MEMBERS.

1914.			
June	8	W. H. Foster..$	5.00
"	8	D. P. Kellogg..	5.00
"	8	W. C. Peterson.	5.00
"	8	T. W. Younger.	5.00
"	8	W. T. Small...	5.00
"	8	G. H. Likert...	5.00
"	10	J. F. Newhouse	5.00
"	10	J. B. Michael..	5.00
"	10	J. Hainen	5.00
"	10	C. M. Stuart...	5.00
		Carried forward ......$	50.00

		Brought forward ......$	50.00
June	10	J. H. Painter...	5.00
"	10	R. F. Kilpatrick	5.00
"	10	J. B. Kilpatrick	10.00
"	10	M. R. Smith...	5.00
"	10	J. S. Breyer....	5.00
"	10	B. McBride ...	5.00
"	10	E. L. Akans....	5.00
"	10	E. R. Webb....	5.00
"	10	D. H. Deeter..	5.00
"	10	J. P. Laux.....	5.00
		Carried forward ......$	105.00

Brought forward ......$		105.00
June 10	C. W. Allen....	5.00
" 10	G. Wagstaff ..	5.00
" 10	C. E. Keenen...	5.00
" 10	C. Phillips	5.00
" 10	J. E. Gould....	5.00
" 10	C. H. Terrell..	5.00
" 10	W. S. Jackson..	5.00
" 10	R. Patterson ..	5.00
" 10	J. Markey	5.00
" 10	C. M. Muchnick	5.00
" 15	T. S. Davey....	10.00
" 15	W. H. Hill....	5.00
" 15	R. A. Haug....	5.00
" 15	A. J. Snell.....	5.00
" 15	G. A. Gallagher	5.00
" 15	W. E. Dunham	5.00
" 15	W. A. George..	5.00
" 15	G. Moll	10.00
" 15	W. C. Arp.....	5.00
" 15	O. H. Runnels.	5.00
" 15	R. C. Pattison..	5.00
" 15	H. F. Staley...	5.00
" 15	D. J. Durrell..	5.00
" 15	R. Atkinson ...	5.00
" 15	T. D. Mannion.	5.00
" 15	G. L. Van Dorn	5.00
" 15	H. G. Reid....	5.00
" 15	J. Burns	5.00
" 15	C. Kyle	5.00
" 15	J. H. Mills....	5.00
" 15	A. Dixon	5.00
" 15	W. C. Hayes..	5.00
" 15	N. E. Sprowl..	5.00
" 15	J. H. Stranahan	5.00
" 15	E. G. Gross....	5.00
" 15	J. A. Boyden..	10.00
" 15	C. E. Chambers	5.00
" 15	C. A. Kothe....	5.00
" 15	F. C. Pickard..	5.00
" 15	J. J. O'Neil....	5.00
" 15	J. E. McQuillen	5.00
" 15	J. F. Marriott..	5.00
" 15	P. C. Withrow.	5.00
Carried forward ......$		335.00

Brought forward ......$		335.00
June 15	H. S. Rauch...	5.00
" 15	H. W. Martin..	5.00
" 15	O. J. Kelly....	5.00
" 15	J. E. Layden...	5.00
" 15	S. A. Chamberlin	5.00
" 15	C. J. Drury....	5.00
" 16	E. J. Brennan..	5.00
" 16	M. A. Kinney..	5.00
" 16	C. H. Rae......	5.00
" 16	G. W. Deats...	5.00
" 16	L. R. Pomeroy.	5.00
" 16	J. F. Hill......	5.00
" 16	S. L. Bean.....	5.00
" 16	A. G. Machesney	5.00
" 16	W. M. Perrine.	5.00
" 16	V. C. Randolph	5.00
" 16	T. F. Barton...	5.00
" 16	P. H. Munshull	5.00
" 16	J. R. Gould....	5.00
" 16	M. Flanagan...	5.00
" 17	B. R. Moore...	5.00
" 23	G. F. Tilton...	5.00
" 23	W. S. Trout...	5.00
" 23	M. K. Barnum.	5.00
" 23	H. W. Martin.	5.00
" 23	L. L. Smith....	5.00
" 23	T. B. Jennings.	5.00
" 23	F. L. Tuma....	5.00
" 23	A. Williams ...	15.00
" 23	H. P. Durham.	10.00
" 23	J. P. Dolan....	5.00
" 23	C. S. Hall......	10.00
" 23	C. Graham.....	5.00
" 23	E. N. Wiest...	5.00
" 23	C. W. Lee.....	5.00
" 23	H. Ashton	5.00
" 23	W. H. Mahoney	5.00
" 23	J. E. Davis....	5.00
" 23	J. W. Taylor...	25.00
" 23	D. G. Desmond	5.00
" 25	G. S. Edmonds.	5.00
" 25	W. H. Owens..	10.00
" 25	T. W. Gentry..	15.00
Carried forward ......$		605.00

Brought forward		......$	605.00
June	25	W. P. Carroll..	5.00
July	1	H. C. May.....	5.00
"	1	W. B. Leach...	5.00
"	1	H. F. Ball.....	5.00
"	1	S. Watson	5.00
"	1	G. F. Hess.....	5.00
"	1	G. N. Riley....	5.00
"	1	R. J. Gross....	5.00
"	1	F. M. Baumgardner	5.00
"	1	J. J. Connors..	20.00
"	1	A. W. Gibbs...	5.00
"	1	G. L. Dickson..	5.00
"	1	W. F. M. Goss.	5.00
"	1	F. W. Brazier..	5.00
"	1	C. H. Andrus..	5.00
"	1	H. R. Thompson	5.00
"	1	S. M. Vauclain.	5.00
"	1	O. G. Hartman.	5.00
"	1	J. W. Cross....	5.00
"	1	W. D. Arter...	5.00
"	1	J. E. Sague....	5.00
"	1	J. H. Manning.	5.00
"	1	N. B. Warren..	5.00
"	1	F. J. Walsh....	5.00
"	1	T. W. McCarthy	5.00
"	1	G. E. Parks....	5.00
"	1	H. C. Gillespie.	5.00
"	1	G. M. Basford..	5.00
"	1	J. S. Bell......	5.00
"	1	S. B. Riley....	5.00
"	1	C. W. Stevenson	10.00
"	1	W. L. Allison..	5.00
"	1	J. A. Carney...	5.00
"	1	T. A. Lawes...	5.00
"	1	J. Purcell	5.00
"	1	W. Q. Dougherty	5.00
"	1	W. H. Davis...	5.00
"	1	J. E. O'Hearne	5.00
"	2	T. H. Curtis...	5.00
"	2	C. H. Howard.	5.00
"	2	F. P. Roesch...	5.00
"	2	N. M. Paul....	5.00
Carried forward		......$	835.00

Brought forward		......$	835.00
July	2	J. A. Graham..	5.00
"	2	C. H. Hogan..	5.00
"	2	H. Emerson ..	5.00
"	2	H. B. Hunt....	5.00
"	2	C. H. Jones....	5.00
"	2	W. G. Babcock.	5.00
"	2	W. H. Wilson..	5.00
"	2	L. L. Bentley...	5.00
"	2	E. Becker	5.00
"	2	J. B. Canfield..	5.00
"	2	F. T. Hyndman	5.00
"	2	G. W. Wildin..	5.00
"	2	A. B. Johnson.	5.00
"	2	B. Haskell	5.00
"	2	P. J. Colligan...	5.00
"	2	J. K. Booth....	5.00
"	2	J. R. Magarvey	5.00
"	2	G. W. Rink....	5.00
"	2	G. A. Moriarty.	5.00
"	2	A. R. Ayers....	5.00
"	2	W. S. Gallaway	5.00
"	2	J. C. Glass.....	5.00
"	2	G. R. Henderson	5.00
"	3	H. B. Ayers...	5.00
"	3	W. H. Marshall	5.00
"	3	W. H. V. Rosing	5.00
"	3	R. Quayle.....	5.00
"	3	C. K. Shelly...	5.00
"	3	L. P. Lafflin...	5.00
"	3	L. A. Shepard.	5.00
"	3	W. L. Reid....	5.00
"	3	Wm. Schlafge.	5.00
"	9	Thos. Marshall.	5.00
"	9	G. M. Gray....	5.00
"	9	J. J. Monahan.	5.00
"	9	J. R. Groves...	5.00
"	9	F. A. Lovell...	5.00
"	9	G. C. Bishop...	5.00
"	9	H. Montgomery	5.00
"	9	W. H. Stocks..	5.00
"	9	D. A. Wightman	5.00
"	9	D. J. Justice...	5.00
"	9	J. W. Storey...	5.00
Carried forward		......$	1,050.00

Brought forward			$1,050.00
July	9	W. D. Robb....	5.00
"	9	C. F. Street....	5.00
"	9	G. W. Robb....	5.00
"	9	C. D. Barrett..	5.00
"	9	I. B. Thomas...	5.00
"	9	W. May	5.00
"	9	N. L. Austin...	5.00
"	9	J. A. Beamer...	5.00
"	9	J. L. Greatsinger	5.00
"	9	J. H. Leyonmark	5.00
"	9	C. D. Hilferty..	5.00
"	9	B. D. Lockwood	5.00
"	9	A. E. Manchester	5.00
"	9	G. Lanza	5.00
"	9	G. H. Emerson.	5.00
"	9	F. A. Delano...	5.00
"	9	T. Roope	5.00
"	9	J. Davis	5.00
"	9	J. H. McConnell.	5.00
"	9	Geo. Gurry ...	5.00
"	9	G. S. Hodgins..	5.00
"	9	P. Wallis	5.00
"	9	J. K. Brassell..	5.00
"	9	E. W. Alling...	5.00
"	9	O. R. Hale.....	5.00
"	9	W. O. Thompson	5.00
"	9	F. F. Hanks...	5.00
"	9	J. A. Egan....	5.00
"	9	R. M. McDougall	5.00
"	9	J. F. Walsh....	5.00
"	9	W. Jackson....	5.00
"	9	W. N. Best....	5.00
"	10	E. G. Haskins..	5.00
"	10	T. E. Keyworth	5.00
"	10	C. F. Giles.....	5.00
"	10	C. J. Mellin....	5.00
"	10	F. F. Gaines...	5.00
"	10	F. M. McNulty	5.00
"	10	H. Bartlett	5.00
"	10	M. W. Lewis..	5.00
"	10	Geo. Gilmour ..	5.00
"	10	C. H. Wiggin..	5.00
"	10	Wm. McIntosh.	5.00
Carried forward			$1,265.00

Brought forward			$1,265.00
July	10	C. Coleman	5.00
"	10	J. T. Hayes....	5.00
"	10	J. McNaughton.	5.00
"	10	I. N. Kalbaugh.	5.00
"	10	A. L. Humphrey	5.00
"	10	J. A. Ralston..	5.00
"	10	H. A. Gillis....	5.00
"	10	J. P. Kendrick.	5.00
"	10	A. M. Waitt...	5.00
"	10	W. A. Rogers..	5.00
"	10	T. Paxton	5.00
"	14	B. B. Cargo....	5.00
"	14	D. R. MacBain.	5.00
"	14	P. P. Mirtz....	5.00
"	14	H. E. Smith...	5.00
"	14	Jos. Chidley ...	5.00
"	14	B. F. Kuhn....	5.00
"	14	M. D. Franey..	5.00
"	14	O. M. Foster...	5.00
"	14	W. C. A. Henry.	5.00
"	14	G. E. Sisco....	5.00
"	14	L. S. Randolph.	15.00
"	14	C. M. Harris...	5.00
"	14	D. M. Perine..	5.00
"	14	P. L. Grove....	5.00
"	14	C. B. Keiser...	5.00
"	14	G. S. McKee...	5.00
"	14	G. H. Bussing..	5.00
"	14	J. F. Sheahan..	5.00
"	14	W. J. Rusling..	5.00
"	14	H. P. Meredith	5.00
"	14	J. Horigan	5.00
"	14	F. F. Small...	5.00
"	14	C. G. Turner...	5.00
"	14	W. W. Atterbury	5.00
"	14	T. W. Adams..	5.00
"	14	J. W. Fogg....	5.00
"	14	A. W. Byron..	5.00
"	14	H. W. Jacobs..	5.00
"	14	J. B. Emory...	5.00
"	14	F. A. Torrey...	5.00
"	14	W. H. Dooley.	5.00
"	14	M. H. Strauss.	5.00
Carried forward			$1,490.00

Brought forward		......	$1,490.00
July	14	J. Howard	5.00
"	14	L. M. Jacobs...	5.00
"	14	P. M. Hammett	5.00
"	14	B. E. Greenwood	5.00
"	14	H. B. McFarland	5.00
"	14	F. W. Williams	5.00
"	14	J. G. Neuffer..	5.00
"	14	W. J. McLean.	5.00
"	14	A. W. Horsey.	5.00
"	14	A. B. Todd....	15.00
"	14	S. P. Bush......	5.00
"	14	P. H. Brangs..	5.00
"	14	J. Dickson.....	5.00
"	14	J. L. Roach....	5.00
"	14	W. F. Walsh...	5.00
"	14	G. J. Duffey...	5.00
"	14	J. H. Tinker...	5.00
"	17	R. B. Kendig..	5.00
"	17	H. R. Warnock	5.00
"	17	W. F. Kapp...	5.00
"	17	C. T. Noyes...	5.00
"	17	C. H. Stroud..	5.00
"	17	F. J. Harrison.	5.00
"	17	G. L. Fowler..	5.00
"	17	J. W. Oplinger.	5.00
"	17	L. H. Turner..	5.00
"	17	C. Bowersox ..	5.00
"	17	C. R. Williams.	5.00
"	17	G. K. Hatz....	5.00
"	17	R. W. Bell....	5.00
"	17	J. H. Nash.....	5.00
"	17	LeGrand Parish	5.00
"	17	C. H. Potts....	5.00
"	17	S. W. Miller...	5.00
"	17	P. F. Smith....	5.00
"	17	L. B. Jones...	5.00
"	17	J. H. Fulmor..	5.00
"	17	S. L. Kneass...	5.00
"	17	J. L. Cunningham	5.00
"	17	J. Milliken	5.00
"	17	H. S. Hayward	5.00
"	17	C. D. Porter...	5.00
"	17	A. S. Vogt.....	5.00
Carried forward		......	$1,715.00

Brought forward		......	$1,715.00
July	17	H. A. Hoke....	5.00
"	17	W. F. Kiesel...	5.00
"	17	C. D. Young...	5.00
"	17	W. O. Dunbar.	5.00
"	17	H. C. Manchester	5.00
"	17	R. D. Smith...	5.00
"	17	W. D. Bunker.	5.00
"	29	D. F. Crawford	5.00
"	29	T. R. Cook....	5.00
"	29	J. P. Nolan....	5.00
"	29	C. W. Seddon.	5.00
"	29	H. M. Pflager.	5.00
"	29	J. F. Dunn.....	5.00
"	29	J. A. Hill......	5.00
"	29	F. Zeleny	5.00
"	29	H. H. Maxfield.	5.00
"	29	B. P. Flory....	5.00
"	29	W. J. Tollerton.	5.00
"	29	L. H. Fry......	5.00
"	29	C. B. Young...	5.00
"	29	W. H. Richmond	5.00
"	29	W. R. McKeen.	5.00
"	29	C. E. Fuller....	5.00
"	29	G. A. Miller...	5.00
"	29	J. F. Enright...	5.00
"	29	E. A. Miller...	5.00
"	29	T. Hamilton ...	5.00
"	29	A. G. Kantmann	5.00
"	29	A. M. Darlow..	5.00
"	29	J. W. Small...	5.00
"	29	F. E. Davisson.	5.00
"	29	O. C. Wright...	5.00
"	29	T. W. Demarest	5.00
"	29	T. W. Heintzelman	5.00
"	29	Wm. Dalton ...	5.00
"	29	F. J. Cole......	5.00
"	29	W. T. Thompson	5.00
"	29	H. H. Vaughan.	5.00
"	29	H. L. Leach....	5.00
"	29	L. D. Freeman.	5.00
"	29	S. J. Hungerford	5.00
Carried forward		......	$1,915.00

Brought forward		......	$1,915.00
July	29	G. J. Churchward	5.00
"	29	C. F. Deaner...	5.00
"	29	R. L. Stewart..	15.00
"	29	A. C. Adams...	5.00
"	29	R. T. Jaynes...	5.00
"	29	C. H. Quereau.	5.00
"	29	J. M. Lynch...	5.00
"	29	I. W. Fowle....	5.00
"	29	H. E. Stout....	5.00
"	30	W. H. Traver.	5.00
"	30	H. L. Dresser..	5.00
"	30	H. C. Eich.....	5.00
"	30	J. W. Cloud...	5.00
"	30	A. J. Hill......	5.00
"	30	H. T. Thomas..	5.00
"	30	W. E. Maxfield	5.00
"	30	C. N. Goodall..	5.00
"	30	H. M. Curry...	5.00
"	30	H. C. Stevens..	5.00
"	30	J. G. Blunt.....	5.00
Aug.	7	J. Gill	5.00
"	7	H. M. Miller..	5.00
"	7	E. Dawson	5.00
"	7	R. E. Smith....	5.00
"	7	C. L. Meister....	5.00
"	7	P. Krassovsky..	5.00
"	7	T. Fraser	5.00
"	7	Wm. Boughton.	5.00
"	7	R. A. Smart....	10.00
"	7	J. C. Ramage..	5.00
"	7	C. E. Slayton...	5.00
"	7	L. L. Collier...	5.00
"	7	F. C. Cleaver...	5.00
"	7	Wm. Elmes	5.00
"	7	G. C. Gardner.	5.00
"	7	J. A. Cassady..	5.00
"	7	I. M. Malone..	10.00
"	7	C. R. Ord......	5.00
"	7	Geo. Gibbs	5.00
"	7	R. E. Maunsell.	5.00
"	7	H. W. Ridgeway	5.00
"	7	W. J. O'Brien.	5.00
Carried forward		......	$2,145.00

Brought forward		......	$2,145.00
Aug.	7	J. C. Mengel...	5.00
"	7	E. Summer	5.00
"	7	W. H. Bennett.	5.00
"	7	R. K. Reading..	5.00
"	7	A. R. Kipp.....	5.00
"	7	T. A. Foque...	5.00
"	7	J. H. Clark....	5.00
"	7	H. Fowler	5.00
"	7	F. S. Anthony..	5.00
"	7	A. Kearney ...	5.00
"	7	J. A. Pilcher...	5.00
"	7	W. H. Lewis...	5.00
"	7	H. F. Greenwood	5.00
"	29	Chas. Woodard	5.00
"	29	W. M. Campbell	5.00
"	29	H. Rhoads	5.00
"	29	F. T. Slayton..	5.00
"	29	R. V. Wright..	5.00
"	29	D. E. Cassidy..	5.00
"	29	C. W. Cross...	5.00
"	29	T. H. Y. Newcomb	5.00
"	29	E. C. Haggett..	10.00
"	29	J. M. Burley...	5.00
"	29	E. A. Bridges..	5.00
"	29	D. E. Davis....	5.00
"	29	E. W. Pratt...	5.00
"	29	A. Turner	5.00
"	29	H. T. Bentley..	5.00
"	29	J. E. O'Hearne.	5.00
"	29	J. J. Conolly...	5.00
"	29	J. D. Maupin..	5.00
"	29	M. G. Brown...	5.00
"	29	Geo. Thompson	5.00
"	29	S. G. Thomson.	5.00
"	29	C. L. Gaspar...	5.00
"	29	H. R. Kight....	5.00
"	29	S. M. Dolan...	5.00
"	29	W. H. Sagstetter	5.00
"	29	A. J. Monfee...	5.00
"	29	E. W. Burgis..	5.00
"	29	E. C. Schmidt..	5.00
"	29	G. F. Wieseckel	5.00
Carried forward		......	$2,360.00

Brought forward			$2,360.00
Aug.	29	P. H. Murphy..	5.00
"	29	F. A. Smock...	5.00
"	29	W. B. Russell..	5.00
"	29	J. Cullinan	5.00
"	29	W. A. Smith...	5.00
"	29	J. T. Flavin...	5.00
"	29	Wm. Ewald ...	5.00
"	29	T. A. Brown...	5.00
"	29	R. English.....	5.00
"	29	J. M. Henry...	5.00
"	29	F. G. Grimshaw	5.00
"	29	C. F. Chase....	5.00
"	29	T. Ross	5.00
"	29	W. Kells	5.00
"	29	J. N. Mowery..	5.00
"	29	J. Shelaberger.	5.00
"	29	W. E. New....	5.00
"	29	W. H. Flynn...	5.00
"	29	O. S. Jackson..	5.00
"	29	F. O. Walsh...	5.00
"	31	J. H. Scott.....	5.00
"	31	F. H. Litton...	5.16
Sept.	5	J. M. James....	5.00
"	5	T. M. Neel....	5.00
"	5	H. Hardie	5.00
"	5	J. E. Mechling.	5.00
"	5	J. C. Seeger...	5.00
"	5	M. H. Haig....	5.00
"	5	Yas Shima	5.00
"	5	J. E. Keegan...	5.00
"	10	S. J. Dillon....	5.00
"	10	W. B. Combs..	5.00
"	10	E. F. Needham.	5.00
"	10	J. Wahlen	5.00
"	22	H. L. Cole.....	5.00
"	22	E. E. Lucy....	5.00
"	22	T. Lyon	5.00
"	22	Jas. Marchbanks	5.00
"	22	C. B. Royal....	5.00
"	22	W. C. Burel....	5.00
"	22	C. B. Smith....	5.00
"	22	J. G. Beaumont	5.00
"	22	W. L. Kellogg.	5.00
Carried forward			$2,575.16

Brought forward			$2,575.16
Sept.	22	H. J. Tierney..	5.00
"	29	J. W. Harkom.	5.00
"	29	W. H. Hamilton	5.00
"	29	J. J. Sullivan...	10.00
"	29	F. Mertsheimer	5.00
"	29	J. T. Hogwood.	5.00
Oct.	8	A. G. Leonard.	5.00
"	8	A. L. Graburn.	5.00
"	8	D. J. Mullin...	5.00
"	8	F. K. Murphy..	5.00
"	8	W. E. Ricketson	5.00
"	8	Geo. Ridgway..	5.00
"	17	J. S. Allport...	5.00
"	17	E. H. Sweeley.	5.00
"	17	G. E. Knight...	5.00
"	17	J. H. Davis.....	5.00
"	17	J. T. Carroll...	5.00
"	17	F. H. Clark....	5.00
"	17	J. Kirkpatrick..	10.00
"	17	P. H. Reeves...	5.00
"	17	F. W. Rhuark.	10.00
"	17	J. T. Luscombe.	5.00
"	17	J. A. Anderson.	5.00
"	17	J. J. McGuire..	5.00
"	17	L. Finegan	5.00
"	17	J. E. Miller....	5.00
"	17	Wm. Sinnot	5.00
"	17	H. Gardner	5.00
"	17	P. Conniff	5.00
"	17	M. J. McCarthy	5.00
"	17	O. C. Cromwell	5.00
"	17	O. J. Kelly.....	5.00
"	17	R. Tawse	5.00
"	30	C. F. Gregory..	5.00
"	30	R. P. C. Sanderson	5.00
"	30	R. E. McCuen.	5.00
"	30	T. L. Button...	15.00
"	30	A. Lovell	5.00
"	30	W. D. Holland.	5.00
"	30	J. J. Carey.....	5.00
"	30	H. W. Johnston	5.00
"	30	D. M. Pearsall..	5.00
Carried forward			$2,810.16

Brought forward		......	2,810.16
Oct.	30	M. C. M. Hatch.	5.00
Nov.	3	J. W. Cyr......	5.00
"	9	E. C. Bates.....	5.00
"	9	A. O. Berry....	5.00
"	21	M. R. Coutant..	5.00
"	21	C. H. Seabrook.	5.00
"	21	A. F. Stewart..	5.00
"	21	W. H. Nuttall..	5.00
"	21	V. Z. Caracristi.	5.00
"	21	A. B. Appler...	5.00
"	28	H. E. Dalzell...	5.00
"	28	W. F. Kaderly..	5.00
Dec.	4	J. J. Waters....	5.00
"	29	W. F. Kapp....	8.30
"	29	A. E. Manchester	197.80
"	29	F. A. Torrey...	174.20
"	29	F. J. Harrison..	32.30
"	29	F. O. Walsh....	7.80
"	29	H. C. May.....	14.30
"	29	F. Dawson	1.00
"	29	R. J. Turnbull..	119.40
"	29	I. N. Kalbaugh.	3.00
"	29	H. C. Manchester	76.00
"	29	J. J. Sullivan...	25.80
"	29	T. Hamilton ..	6.40
"	29	H. Montgomery	9.60
"	29	T. A. Foque...	53.70
"	29	G. M. Crownover	29.40
"	29	W. H. Lewis..	105.00
"	29	D. J. Mullen...	86.50
"	29	R. E. Smith....	81.60
"	29	J. J. Thomas...	28.70
"	29	J. Horrigan	25.70
"	29	R. D. Smith....	39.50
"	29	B. R. Moore...	11.20
"	29	J. F. Enright...	61.70
"	29	B. P. Flory.....	21.20
"	29	J. E. O'Hearne.	34.50
"	29	F. F. Gaines...	33.60
"	29	H. W. Ridgway	19.70
"	29	M. E. Cleland..	15.00
"	20	A. A. Maver...	5.00
"	29	T. G. Ferguson.	5.00
Carried forward		......	$4,203.06

Brought forward		......	$4,203.06
Dec.	29	C. R. Hillman..	5.00
"	29	H. H. Vaughan	225.90
"	29	A. Sinclair.....	5.00
1915.			
Jan.	8	G. T. Depue....	5.00
"	8	G. H. Haselton.	5.00
"	8	D. Van Alstyne.	5.00
"	8	D. W. Cunningham	5.00
"	8	P. L. Raymond.	5.00
"	8	F. D. Davis....	5.00
"	8	H. Rhoads	5.00
"	8	W. E. Symons.	5.00
"	8	G. H. Baker....	5.00
"	8	R. E. French...	5.00
"	8	L. H. Turner...	25.60
"	8	W. H. Hill.....	.60
"	8	T. W. Demarest.	114.80
"	8	G. S. McKee...	9.40
"	8	H. R. Warnock.	26.30
"	8	P. F. Smith....	18.10
"	8	G. C. Bishop....	18.20
"	8	O. S. Jackson..	7.30
"	8	W. F. Kaderly..	6.50
"	8	M. A. Kinney..	15.60
"	8	G. W. Wildin..	130.40
"	8	Wm. Schlafge .	150.10
"	8	M. R. Coutant.	10.00
"	27	H. D. Gordon..	5.00
"	27	A. S. Abbott...	5.00
"	27	G. A. Hancock.	10.00
"	27	P. Maher	5.00
"	27	M. K. Tate.....	5.00
"	27	F. S. Hoffmaster	5.00
"	27	W. T. Fitzgerald	5.00
"	27	J. A. McRae....	5.00
"	27	A. A. Bannatyne	5.00
"	27	H. M. C. Skinner	5.00
"	27	N. B. Scanland.	5.00
"	27	C. J. Stewart...	5.00
"	27	C. A. Seley.....	5.00
"	27	C. W. Werst...	5.00
"	27	P. J. Meade....	5.00
"	27	M. E. Sherwood	5.00
Carried forward		......	$5,101.86

		Brought forward	$5,101.86
Jan.	27	G. A. Bruce	5.00
"	27	J. McManamy	5.00
"	27	S. M. Woodruff	5.00
"	27	A. M. White	5.00
"	27	H. W. Coddington	5.00
"	27	S. W. Mullinix	5.00
"	27	A. Dinan	5.00
"	27	C. E. Slayton	2.30
"	27	C. E. Fuller	82.20
"	27	F. Mertsheimer	6.20
"	27	J. R. Gould	83.00
"	27	Wm. Ewald	2.60
"	27	E. A. Miller	24.40
"	27	G. A. Miller	11.80
"	27	H. M. Curry	135.60
"	27	J. T. Flavin	14.50
"	27	T. W. Heintzleman	141.00
"	27	M. G. Brown	4.90
"	27	R. W. Bell	166.70
"	27	J. L. Smith	5.00
"	27	W. H. Flynn	75.60
"	27	W. C. A. Henry	78.00
"	27	F. S. Yenawine	11.20
"	27	F. E. Davisson	16.90
"	27	J. F. Sheahan	8.60
"	27	G. F. Hess	19.50
"	27	J. W. Small	52.50
"	27	H. T. Thomas	3.40
"	27	F. T. Hyndman	20.80
"	27	B. H. Gray	5.80
"	29	J. W. Fogg	4.60
"	29	Thos. Fraser	3.30
"	29	G. M. Gray	17.80
"	29	C. Manley	2.70
"	29	W. J. Tollerton	167.80
"	29	D. R. MacBain	99.50
"	29	Thos. Hickson	5.00
"	29	J. J. Irvin	5.00
"	29	Geo. Dickson	5.00
"	29	E. J. Smith	5.00
"	29	A. Allan	5.00
		Carried forward	$6,430.06

		Brought forward	$6,430.06
Jan.	29	E. A. Park	3.30
Feb.	3	J. Purcell	215.20
"	3	W. H. Dooley	34.70
"	3	F. C. Ferry	5.00
"	9	Thos. Maher	5.00
"	9	H. A. Mullet	5.00
"	9	R. B. Watson	5.00
"	9	J. H. Daley	5.00
"	9	H. C. Oviatt	5.00
"	9	G. B. Walsh	5.00
"	9	A. J. Wood	5.00
"	9	C. D. Vanaman	5.00
"	9	H. R. Warnock	5.00
"	9	L. L. Dawson	8.80
"	10	C. M. Stansbury	5.00
"	10	C. F. Roberts	5.00
"	10	J. A. Turner	5.00
"	10	J. M. Johnston	5.00
"	10	L. L. Dawson	5.00
"	10	W. L. Kellogg	68.90
"	10	A. J. Fries	5.00
"	18	S. Shepard	5.00
"	18	W. G. Edmondson	5.00
"	18	Wm. Lachlan	5.00
"	18	C. H. Prescott	5.00
"	18	H. M. Carson	5.00
"	18	W. A. Bedell	5.00
"	18	J. Cullinan	1.00
"	18	Jas. Milliken	32.80
Mar.	31	R. E. Bell	5.00
"	31	A. S. Teague	10.00
"	31	Geo. Thompson	4.40
"	31	B. H. Gray	5.00
"	31	E. G. Sasser	10.00
"	31	F. L. Carson	5.00
"	31	M. G. Bock	.60
"	31	J. A. Riberio	5.00
"	31	R. Schultheiss	5.00
"	31	J. H. Feehan	5.00
"	31	J. K. Brassill	6.60
"	31	R. Gould	5.00
"	31	J. Wahlen	1.00
		Carried forward	$6,972.36

Brought forward			$6,972.36
Mar.	31	H. Y. Harris...	5.00
"	31	H. Y. Harris..	.80
"	31	A. G. Sandman	5.00
"	31	J. H. Manning.	49.10
"	31	J. E. Muhlfeld.	5.00
"	31	J. S. Siverwright	5.00
"	31	F. W. Nelson..	5.00
"	31	J. W. Gibbs....	5.00
"	31	L. A. Richardson	5.00
"	31	S. K. Dickerson	5.00
"	31	H. H. Hale....	5.00
"	31	T. Rumney....	5.00
"	31	E. Graham	5.00
"	31	F. H. Reagan..	5.00
"	31	H. J. Small....	5.00
"	31	G. H. Watkins.	5.00
"	31	L. R. Johnson..	5.00
"	31	D. W. Fitzgerald	5.00
April	16	F. W. Taylor...	18.40
"	16	R. L. Ettenger.	5.00
"	16	B. P. Myers...	5.00
"	16	G. W. Ray.....	10.00
"	16	F. F. Hildreth.	5.00
"	16	G. L. Wall.....	5.00
"	16	F. J. Barry....	5.00
"	16	C. A. Gill.....	5.00
"	16	J. C. Little.....	5.00
"	16	A. W. Lord....	5.00
"	16	E. H. Gorey...	5.00
"	22	W. H. Robinson	5.00
"	22	B. Hartigan ...	5.00
"	22	S. Kobyashi....	15.00
May	1	F. C. Ferry....	5.00
"	1	S. A. Bickford.	5.00
"	1	C. H. Burk....	5.00
"	1	W. H. Watkins.	5.00
"	1	W. H. Watkins	5.00
"	1	W. S. Moseley.	5.00
"	11	G. F. Shull.....	4.70
"	11	J. M. Dow.....	5.00
"	11	E. L. Mauk....	5.00
"	11	E. S. Hume...	5.00
"	11	Jas. Stockton..	5.00
Carried forward			$7,255.36

Brought forward			$7,255.36
May	11	R. Hill	5.00
June	1	H. Osborne	20.00
"	1	D. T. Main....	5.00
"	1	G. Whiteley ...	5.00
"	1	G. C. Bornefeld	10.00
"	1	M. Robinson ..	5.00
"	1	H. H. Harrington	5.00
"	1	W. H. McAmis	5.00
"	1	C. F. Barnhill..	5.00
"	1	W. J. Wilcox..	5.00
"	1	J. R. Van Cleve	15.00
"	1	P. Ryan	5.00
"	1	E. A. Murray..	15.00
"	1	J. H. Leyonmark	5.00
"	1	J. J. Ewing....	5.00
"	1	C. P. Diehr....	5.00
"	1	H. Wanamaker	5.00
"	1	E. E. Machovec	5.00
"	1	J. O. Warthen.	5.00
"	1	W. P. Davis...	5.00
"	1	E. A. Williams.	5.00
"	1	A. Brand	1.80
"	1	Geo. Akans ...	5.00
"	1	W. L. Tracy...	5.00
"	1	F. Quattrone...	5.00
"	1	C. T. Ripley...	5.00
"	1	M. S. Monroe..	15.00
"	1	J. E. Symons...	10.00
"	1	A. A. Harris...	10.00
"	1	W. J. Miller...	15.00
"	1	D. D. Arden...	5.00
"	1	C. L. McIlvaine	5.00
"	1	H. G. Hudson.	5.00
"	1	J. S. Pearce....	5.00
"	1	J. S. Pearce....	5.00
"	1	J. H. McGoff..	5.00
"	1	W. Campbell ..	5.00
"	1	Thos. Jennings.	5.00
"	1	W. H. Rieckmann	5.00
"	1	C. Graham	5.00
"	1	G. M. Crownover	5.00
"	1	J. E. Chisholm.	5.00
"	1	E. Chamberlain.	5.00
"	1	E. G. Chenowith.	5.00
Total			$7,557.16

The Secretary: Last Saturday my books were submitted to a public accountant in Chicago and were found O. K. I was told by the accountants that they would have a letter certifying to that fact here this morning, but it has not yet arrived. The mail from Chicago gets in at about ten o'clock, and I will submit the report of the accountants a little later in the day.

The Secretary then read the Treasurer's report, as follows:

TREASURER'S REPORT.

American Railway Master Mechanics' Association.

RECEIPTS.

1914.	
June 9, balance on hand as per last report	$ 941.51
June 29, interest on deposits, April, May, June	4.53
September 1, coupons from New York City bonds	106.25
September 29, interest on deposits, July, August, September	4.70
December 1, coupon from Jerome & Wheelock bond	20.00
December 29, interest on deposits, October, November, December.	4.98
1915.	
March 1, coupons from New York City bonds	106.25
March 30, interest on deposits, January, February, March	5.06
June 1, coupon from Jerome & Wheelock bond	20.00
Total	$1,213.28
June 7, balance on hand (and as per bank book)	$1,213.28

Respectfully submitted,

Angus Sinclair,
Treasurer.

The President: What action will you take upon the report of the Treasurer? A motion is in order to receive the Treasurer's report and refer it to an Auditing Committee.

Mr. D. R. MacBain (N. Y. C. R. R.): I move that the report of the Treasurer be received and referred to an Auditing Committee.

Motion seconded and carried.

The President: It is now in order to receive nominations for members of the Auditing Committee.

The following nominations for members of the Auditing Committee were then made and approved:

Mr. W. E. Dunham, Mr. M. D. Franey and Mr. M. H. Haig.

THE PRESIDENT: If there are no objections these gentlemen will stand as the Auditing Committee.

THE SECRETARY: I will say to the members of the Auditing Committee that the papers of the Treasurer are on the desk for their inspection at any time, and later in the day I will provide them with the report of the public accountants as to my report.

THE SECRETARY: Regarding our scholarships at the Stevens Institute of Technology, at Hoboken, New Jersey, we have four scholarships and I have the following report from the Registrar:

"Mr. Walter Stoner James, 90 West Newell street, Rutherford, New Jersey, and Harold Willing Alling, 201 Maple street, New Haven, Connecticut, are at present attending under the scholarships of your Association.

"Their grades upon the work of the current year, though not high, are above passing. If there is no falling-off in their scholarship during the remainder of the current year, they will probably continue with their classes. Mr. Alling is a member of the freshman class and Mr. James is a member of the junior class."

It will be seen from the above that there are two vacancies in our scholarships at this Institute.

Regarding the Joseph T. Ryerson & Son Scholarships, I will say that they have increased the amount of their annual donation to cover two scholarships of three hundred dollars each, instead of one scholarship of five hundred dollars. It was also arranged to increase the number of educational institutions at which the scholarships would be available. One scholarship will be vacant in June, 1915. Candidates should make application to the Secretary of the Association, in accordance with the following conditions, which have been established by this committee and under which the scholarships will be awarded. Another scholarship will be available in June, 1916.

During the year thirty-nine inquiries have been received regarding this scholarship, which has resulted in eleven inquirers sending in the required certificates as regards their eligibility.

The Executive Committee will pass upon the applications in

a short time to determine which shall be the successful candidate, so that he can enter the September examinations.

As the circular states. there will be another scholarship next June — June, 1916.

I would like also to call attention again to the fact that there are two vacancies at the Stevens Institute of Technology. I shall notify all the unsuccessful candidates for the Ryerson Scholarship of these vacancies, so that if they wish they can take up the matter of entering the Stevens Institute.

Last year a proposed change in the Constitution was submitted in regard to the payment of dues. It was proposed to change Article III, Section 3, to read as follows:

> All active and associate members of the Association, excepting as hereafter provided, shall be subject to the payment of such annual dues as it may be necessary to assess for the purpose of defraying the expenses of the Association, provided that no assessment shall exceed $5 a year.

In Article III, Section 3, Paragraph 2, it is proposed to have it read as follows:

> A representative member shall pay, in addition to his personal dues as above, an amount for each additional vote to which he is entitled, as shall be determined each year by the Executive Committee, prorated upon the cost of conducting such tests as may be determined upon at each convention.

THE PRESIDENT: A motion to adopt these amendments to the Constitution, regarding membership fees, is in order.

MR. MACBAIN: I move that the amendments to the Constitution, as just read, be adopted.

Motion seconded and carried.

THE PRESIDENT: As you understand, gentlemen, that makes a change in the Constitution regarding dues. I would like to say one word about the matter of fees of representative membership. We have been pretty hard pressed financially for the last three years; quite a large number of the roads in various parts of the country have come in and taken representative membership, and that has helped us out to some extent, but many of the roads have not done so. I hope you gentlemen when you go back home to your respective roads will urge your general managers,

or vice-presidents, or whoever may be the proper party with whom to take up this matter, that they will approve of the members of the Association acquiring this representative membership, because it is quite necessary for us to have the money which such representative membership will bring if we are to prosecute the work of the Association in a diligent manner.

THE SECRETARY: The following committees on obituaries have been appointed:

C. J. McMASTERS, Rutland R. R. .... H. MONTGOMERY.
T. E. ADAMS, St. L. S. W. Ry .... P. T. DUNLAP.
E. A. MILLER, N. Y. C. & St. L. Ry......... T. A. LAWES.
W. H. TRAVER, Chicago Pneumatic Tool Co.. THOS. ALDCORN.
A. STEWART, Southern Ry.................. JOS. HAINEN.
W. S. MORRIS.............................. T. W. DEMAREST.
WILLIAM McINTOSH .... ANGUS SINCLAIR.
COLUMBUS PHILLIPS, N. O. & N. E. R. R..... C. F. GILES.
A. B. ADAMS, G. C. S. F. Ry................ J. E. McQUILLAN.
E. B. GILBERT, B. & L. E. R. R.............. G. M. GRAY.
J. P. McCUEN, C. N. O. & S. P. Ry......... W. H. DOOLEY.
P. P. MIRTZ, N. Y. C. R. R................. R. B. KENDIG.
B. B. CARGO, Lake Terminal R. R.......... G. N. RILEY.
E. T. WHITE, B. & O. R. R................. M. K. BARNUM.
JOHN PLAYER .... J. W. TAYLOR.
J. M. FOSS, Central Vermont................ W. GILLESPIE.
J. I. KINSEY, Lehigh Valley................ N. H. HIBBITS.
C. A. THOMPSON.......................... J. W. TAYLOR.
C. J. DRURY, S. S., St. L. & S. F. Ry........ M. H. HAIG.
M. E. SHERWOOD, Mich. Central R. R........ W. H. FLYNN.

THE SECRETARY: At a meeting of the Executive Committee held last evening the question of a change in the hour for holding the election of officers, which was referred during the closing hours of the convention of 1914, to the Executive Committee, was considered. It was thought that the plan now in force in Master Car Builders' Association, should be adopted by this Association and to conform thereto the following changes in the constitution are proposed:

Article IV, Sec. 1, changed to read: The officers of the Association shall be a President, a First Vice-President, a Second Vice-President, a Third Vice-President, a Treasurer, a Secretary and a Committee on Nominations of five members. The six Executive Members, with the

President, Vice-Presidents and Treasurer, shall constitute the Executive Committee of the Association.

Article VI, Sec. 5 (new section): The Executive Committee shall offer to the convention the names of ten active or representative members, not officers of the Association, as candidates for the Committee on Nominations, provided that on the adoption of these amendments the President will appoint a Committee on Nominations of five members to serve until their successors are elected.

Article VI, Sec. 6 (new section): It shall be the duty of the Committee on Nominations to offer to the convention the name of one member as a candidate for each of the following offices:

The President, First Vice-President, Second Vice-President, Third Vice-President and Treasurer, and the names of three members as candidates for Executive Members. Each person so named shall be either an active or representative member of the Association.

When twenty or more members desire to propose the name of a member for any office in place of the name suggested by the Committee on Nominations, the Secretary shall place the name of such member for said office on the printed ballot, making a statement to the effect that such name has been proposed by a certain number of members.

The Secretary then read the matter under "Elections" from the Constitution of the Master Car Builders' Association, Article VIII, Sections 9 and 10, and proposed this additional new section:

Sec. 11. Printed ballots for use in the election of officers, executive members, the Committee on Nominations and for associate and life members shall be of the form appended hereto.

THE SECRETARY: This notice will lie over until the next convention, in accordance with the requirements of the constitution.

THE PRESIDENT: Perhaps it would be in order to have a motion made that this notice of amendment be received and that it lie over until the next meeting. You have heard the report of the Secretary, and it will be in order to have this proposed amendment lie over until the next meeting when it will be taken up and acted upon. I feel very strongly on this matter, because with very slight exceptions, the plan which has been outlined here is the same method used in the Master Car Builders' Association in electing officers. I have attended a great many of these conventions, and it frequently happens that during the last hours of the convention, when the election of officers takes place, there is but a very meager attendance. I believe it is proper to have this

new method of electing our officers so that it will be done in a manner suitable to the dignity of the Association.

MR. DUNHAM: I move that the proposed amendment lie over until the next meeting, and that it be given consideration at that time.

Motion seconded and carried.

THE SECRETARY: At a meeting of the Executive Committee held last evening it was decided to recommend that the dues of active and associate members be fixed at $5 per year, and representative members at $7 per one hundred engines per year.

THE PRESIDENT: What action will you take on this recommendation of the Executive Committee? A motion is in order to approve the action of the Executive Committee.

MR. E. W. PRATT (C. & N. W. Ry.): I move that the action of the Executive Committee be approved.

Motion seconded and carried.

THE SECRETARY: At the meeting of the Executive Committee held last night the application of Mr. Rufus Hill for Honorary Membership in this Association was read. Mr. Hill joined the Association in 1874 and continued as a member until 1880. He then resigned, but renewed membership in 1892 and has been a member ever since. He is now past eighty years of age, and has past the stage when he is physically able to be an active participant in the proceedings of the Association. This application was approved by the Executive Committee and ordered to be referred to the convention for action.

THE PRESIDENT: I think it would be in order to have a motion to elect Mr. Hill an Honorary Member of the Association.

MR. PRATT: I move that Mr. Hill be elected an Honorary Member of the Association.

Motion seconded and carried.

THE SECRETARY: At the meeting of the Executive Committee held last evening the application of Mr. H. G. Bechhold, for election as an Honorary Member of the Association was considered. Mr. Bechhold has been a member of the Association for twenty-two years, and he makes this request to be placed on the Honorary list. The Executive Committee approves his request.

THE PRESIDENT: A motion will be in order to elect Mr. Bechhold an Honorary Member if that is the desire of the members present.

MR. W. C. HAYES (Erie R. R.): I move that Mr. Bechhold be elected as an Honorary Member.

Motion seconded and carried.

THE SECRETARY: Mr. S. G. Thompson, S. M. P. & R. E. of the Reading R. R., wishes me to make this announcement:

"A heavy high speed passenger locomotive, new type 444, will be exhibited at Mississippi avenue and Boardwalk, two blocks south of the pier entrance, by the Philadelphia & Reading Railway Company. This locomotive includes a number of new departures in locomotive design and will no doubt be of interest to all members."

THE SECRETARY: The Committee on Standardization of Tinware, whose report will be considered to-morrow, desires me to announce that it has arranged with the American Car & Foundry Company, whose exhibit will be found the first one on the left as you enter the exhibition hall, to show the standards they recommend in their report. Mr. Johnson, of the Johnson Manufacturing Co., has made up a set of these standards, gratis to the Association, and the committee wishes you to see them.

THE PRESIDENT: I would like to add to the statement of the Secretary that the Storekeepers' Association has done a great deal of work in connection with the standardization of tinware and similar articles in use on the railroads, and we should take some action along those lines. We can certainly save a good deal of money if we have standard tinware, and we should bear that point in mind in looking this exhibit over.

MR. M. D. FRANEY (N. Y. C. R. R.): In connection with the subject I would like to ask the members of the Tinware Committee to meet at the booth of the American Car & Foundry Company right after luncheon to-day, in order that we may look over the articles of tinware.

MR. W. C. HAYES (Erie R. R.): Before proceeding with the regular order of business, I would like to make this announce-

ment: Mr. W. D. Thomson, Secretary, wrote me several weeks ago to represent the Traveling Engineers' Association at this meeting of the American Railway Master Mechanics' Association. I hoped that the Secretary would make that announcement, but fearing he was going to omit it, I take advantage of this opportunity.

THE SECRETARY: I did omit it. I spoke to Mr. Thomson personally, a short time after the convention last year, and asked him to have a representative present.

MR. HAYES: I asked him if he had written to you about the matter, and he said he felt delicate about it and expected to hear from you. I wish to suggest, in order to prevent any delicate situation arising in the future, that Mr. Thomson be invited to send a representative to this meeting, and that this Association make it a part of the minutes that a representative of the Traveling Engineers' Association shall have a regular formal invitation to be present at the Master Mechanics' conventions, and let that go to them as an official announcement.

THE SECRETARY: Who would suggest to represent that Association at this meeting?

MR. HAYES: I was requested by Mr. Thomson to represent the Association at this meeting.

THE SECRETARY: I move that Mr. W. C. Hayes, as the representative of the Traveling Engineers' Association be accorded the privileges of the floor during this convention.

Motion seconded and carried.

MR. HAYES: I thank you, but that is not the point I had in mind when I spoke. What I desire to do is to cover future conventions of the American Railway Master Mechanics' Association, so that there will be no hesitation on our part in electing any member of the Association to represent it at this meeting.

THE SECRETARY: I will state to Mr. Hayes that his suggestion will be referred to the incoming Executive Committee so that provision will be made for extending an invitation to the Travelling Engineers' Association to send a representative to our future meetings.

Mr. Hayes: I thank you for handling the matter in that way. Unfortunately for the Traveling Engineers' Association and the American Railway Master Mechanics' Association, our rules provide that the Past President shall be the official representative. This year, however, on account of increased duties, our Past President, Mr. F. P. Roesch, is unable to be present and represent the Association.

The Secretary: Mr. Wildin has just called my attention to the death of Mr. Wm. McIntosh, a Past President of the Association. Mention of the death of Mr. McIntosh was not included in my report of obituaries, but his name will now be included.

I suggest that Mr. Wildin be requested to prepare an obituary covering the death of Mr. McIntosh, to appear in the Proceedings.

Mr. MacBain: I would inquire whether Mr. M. E. Sherwood, of the Michigan Central, was a member of the Association?

The Secretary: Yes, he joined in 1912.

Mr. MacBain: I presume that most of the members present have heard that he was shot last Friday night by a nine-year-old boy, in Jackson, Mich., and instantly killed. I think it would be appropriate for the Association to take cognizance of the death of Mr. Sherwood, and to extend condolences to his family.

The President: I think it would be highly proper to take the action suggested by Mr. MacBain and extend the condolences of the members of the Association to the widow of Mr. Sherwood. I will therefore appoint Mr. MacBain and Mr. Flynn to prepare resolutions to be presented at the last meeting of the convention.

I will appoint as the Committee on Resolutions the following gentlemen:

D. R. MacBain, E. W. Pratt, L. R. Pomeroy.

Vice-President Pratt in the Chair.

The Vice-President: Mr. Giles has just informed me of the death of Mr. C. Phillips, of the New Orleans & Northeastern. We would like to appoint Mr. Giles to prepare an obituary on his life, for incorporation in the Proceedings.

THE SECRETARY: I have the following letter to present to the convention:

AT ATLANTIC CITY, N. J.

Mr. Joseph W. Taylor, Secretary, American Railway Master Mechanics' and Master Car Builders' Associations:

DEAR SIR, Kindly notify the railroad members of the Master Mechanics' and Master Car Builders' Association desiring transportation home over the lines of the Pennsylvania Railway Company or the Pennsylvania Lines West of Pittsburgh that such transportation will be provided if they submit their requests to you. In accordance with the requirements of law, this transportation must be limited to bona fide officials only, and can not include members of boat lines, car lines or switching roads operated by industries. Yours very truly,

J. T. WALLIS,

General Superintendent Motive Power, Pennsylvania Railroad Lines East of Pittsburgh.

D. F. CRAWFORD,

General Superintendent Motive Power, Pennsylvania Railroad Lines West of Pittsburgh.

THE VICE-PRESIDENT: Is there any further new business, gentlemen? If not, we come to the order of reports. The first report is on Mechanical Stokers. Mr. A. Kearney, A. S. M. P., N. & W. Ry., is the Chairman.

Mr. Kearney presented the report as follows:

REPORT OF COMMITTEE ON LOCOMOTIVE STOKERS.

To the Members:

Another year's experience with the locomotive stoker strengthens the conviction that it is not only accomplishing its purpose, but withstands the test of continuous service with remarkable durability. In previous reports your committee has endeavored to cover a brief description of the principles upon which stoker manufacturers and inventors seem to be working; at the same time group the machines with respect to their dominant features, giving a limited explanation of their operation, characteristics, and to an extent their value using certain grades of fuel under various conditions of operation.

Assuming quite sufficient has been said in magazine articles and individual papers, it was the desire of your committee to present data to show the efficiency of the stoker using some of the different grades of fuel and under varying conditions of operation, as might be secured from a test

plant, but to their regret this has not been possible. However, some observations have been made and some interesting data compiled from their performance in road service.

While it may be said that nothing novel has been presented during the past year, a great deal of very good work has been done along already established lines. The effort has been chiefly in the refinement of detail parts; redesigning and improving them to better withstand the service. In some cases manufacturers have added new parts; in others, parts more durable have been substituted; again, parts have been entirely eliminated. But watching the progress from the outside, one may be impressed with the thought that on the one hand there is that fear of added complication, while on the other the fear that vital features may be disturbed. Still, simplicity is always desirable without the sacrifice of utility, each design is a study in itself, and efficient development can only be made by degrees.

There is no such thought that the stoker is unlike other mechanical devices on the ground that it is not susceptible to failure; and when it gives way it will usually do so under service strains. On the contrary, to meet such a contingency, designs are being studied with the view of fixing the point of failure where repairs can be conveniently made, preferably without a road delay, and when it so happens that repairs can not be made on the road, the emergency can be met by resorting to hand firing until terminal is reached. The theory that the parts of the stoker be amply strong and in excess of the strength of the engine has its advantages.

In the consideration of designs, attention is being given the matter of accessibility of parts, as well as certain features of the locomotive that are now, in some cases, difficult to reach on account of the stoker. The stoker manufacturers have advanced considerably in their attempt to apply machines to existing locomotives, and it is safe to say their work has been somewhat hampered. At the same time, it is reasonable to suppose that if the designs were considered along with those of the locomotive, and both are given equal consideration, more latitude would be offered than is now possible on account of the limited space and the absence of choice in working out certain essential features.

Any of the stokers now in extensive use will, it seems, occasionally become inoperative by clogging. At times it is due to wet coal, then again to lump coal. However, most of the clogging, especially that of a serious nature, is caused by junk and foreign matter, such as spikes, chains, pieces of iron, etc., finding its way to the stoker machinery. Viewing the prevention of such foreign matter reaching the vital parts of the stoker as probably impracticable, the use of a reversible engine has been advocated, and, in fact, is receiving attention, hoping by virtue of its reverse motion to permit the withdrawal of an obstruction without breakage of parts or very much delay. Its value generally, of course, is yet to be conclusively demonstrated.

Time and experience have brought progress in the way of improving

the manipulation of the scatter-type stokers, both in the care of the machine, as well as in a more efficient use of fuel. In the earlier days of the stoker, when the aim was mainly centered upon its continuous and satisfactory operation and ability to cover the division without failure, firemen in many instances habitually shook the grates almost every time the engine stopped, regardless of the condition of the fire. As a result a much thinner bed of fire was carried than economy required. The pop valves were up most of the time. Instructions and experience have effected marked improvement, and now it is rather rare to find a fireman disturbing the grates so long as a sufficient steam pressure is maintained to handle the train efficiently and successfully. The stoker is started, stopped and otherwise controlled with better regulation of fire and less loss of steam through the relief valve. Experience shows that the grates should not be disturbed as long as the fire is maintained in good condition, and the required air is permitted to pass through the grates to supply the proper rate of combustion. Frequently, when it is found necessary to shake the grates, the fire is level to the fire door; at other times it is very light. The maximum depth of the fire should vary with the physical character of the coal, and to a degree with the chemical constituents in the ash. Your committee is of the opinion that where the fireman will use his judgment the operation can be successfully manipulated with less physical exertion, and this precaution will result in reducing loss of fuel through the grates and relief valves, as well as reducing the physical effort on his part.

The cost of stoker maintenance has been somewhat affected in the aggregate during the past year by the modifications, improvements and changes introduced currently. Last year it was thought reference could be consistently made to the cost of maintenance of a certain type, but this year your committee does not feel at liberty to publish data, on account of other stokers becoming prominent by reason of their road service and durability. It may be of interest, however, to mention that from data gathered from the scatter-type stokers in more extensive use, that the cost per 100 miles ranges from 43 cents to 68 cents, and in miles run per failure from 1000 to 5000.

Since the advent of the locomotive stoker it has been an open question as to whether it is more economical to prepare coal at wharves or on the tender of the locomotive. There is strength in the theory that the centralization of crushing plants may be economical under certain service and physical conditions. Then again it is claimed to be good practice in other localities to crush coal at outlying wharves or at coaling tipples, as against equipping locomotives with individual crushers. Duplicate machinery at central stations may minimize inability to supply the proper grade of fuel at a central station, but the cost of such an installation must be carefully weighed, taking into consideration the available fuel, the cost of the individual crusher and maintenance, along

with the less restricted territory in which the engine carrying the self-contained crusher may be used.

The aggregate cost of maintenance of a crusher at a wharf may be less than that for a number of locomotives, and it should not be forgotten that while crushers may be obtained that will fairly well handle the major portion of foreign matter found in fuel, it is conceded difficult to cope with such conditions after it reaches the locomotive. Regardless of this, however, it may be economical to equip locomotives with individual crushers on account of the proportion or volume of fuel supplied, aside from the advantages in being able to handle a wider range in grade of fuel supplied at outlying stations and on branch lines.

During the past year the Norfolk & Western Railway put in operation sixteen Hanna and thirteen Standard stokers. The twenty-nine stokers were provided with crushing facilities on the tender to handle run-of-mine coal. The first few months these stokers were in operation some trouble was experienced while using run-of-mine fuel containing a large proportion of lump, on account of the presence of foreign matter. This, however, has been practically eliminated, or at least very much reduced, by constructing the conveyor to carry such foreign matter within reasonable sizes through to the fire bed with the fuel.

The past year has been marked by the successful performance of the Hanna and Standard stokers, which at the time of your committee's last report had been in actual service but a few months. Fifteen Hanna stokers have been applied to Mallet engines (2-6-6-2), 72.2 sq. ft. of grate area, and twelve Standards to Mastodon engines (4-8-0), 45 sq. ft. grate area, on the same road. They are handling sometimes slack and in other cases run-of-mine coal, from which the product under 2½ in. has been screened. The locomotives equipped with these stokers have been put in general fast and slow freight service, and in many cases the hardest runs on the division for which the respective types of locomotives are selected. These stokers, as well as the Street, have continued their successful work, each having its characteristic features.

The following is a statement of the stokers reported in active service:

Underfeed Type.	Overfeed or Scatter Type.	Chain Grate Type.
Crawford	Street..................	Ayers ....
	Hanna..................	
	Standard...............	
	Kincaid................	

Crawford Stoker.

UNDERFEED.

At the present time there are 292 Crawford double-underfeed stokers in operation on the Pennsylvania Lines West of Pittsburgh. The stoker is still the only underfeed type in service. However, it has been claimed that the Raite stoker (while it has never been tried out) can be operated as either an underfeed or an overfeed type. In addition to the 282 Crawford stokers in service on the Pennsylvania Lines, the following are also in use, being tried out experimentally:

2 on the Bessemer & Lake Erie.

4 on the Vandalia.

3 on the Pennsylvania Lines East of Pittsburgh.

This makes a total of 301 in service. It is reported that a new pattern of the Crawford stoker, known as type "30," is being constructed for test. The above figures show somewhat fewer applications on the Lines West of Pittsburgh than was previously reported, but it is due to the retirement of a number of the earlier designs. While there is no change in the total number of stokers in operation as a year ago, progress continues, and with the advent of the new design it is probable a number will be applied in the near future.

Street Stoker.

OVERFEED OR SCATTER TYPE.

The Street stoker (one of the first, if not the first, to demonstrate its capacity to deliver fuel at a rate in sufficient quantity and regulation to maintain satisfactory steam pressure) still shows the largest number in service, totaling 531, with twenty-four on order, as shown in statement. The type "C" stoker, which is the latest design, has a variable-speed engine and a friction clutch, instead of differential gear that was employed in the earlier type machines. The type "A" machine carried a crusher on the tank, but in the latter designs the crusher was set aside, the conviction being it was better under certain conditions to supply the fuel that would pass through the 2½-in. mesh on the locomotive tender. These stokers are in operation on fifteen railroads. However, from the tabulation showing the distribution of the stokers, it can be seen that most of them are found on eastern roads, the B. & O., N. & W. and C. & O. having eighty per cent of the total number in operation. The Street stokers are operated in passenger, general fast and slow freight service, performing their work satisfactorily. The machines have done remarkable work, on account of their durability, and nothing more is needed in their favor than their record and applications made. The principle upon which the machine is designed and operates is very widely known.

Hanna Stoker.

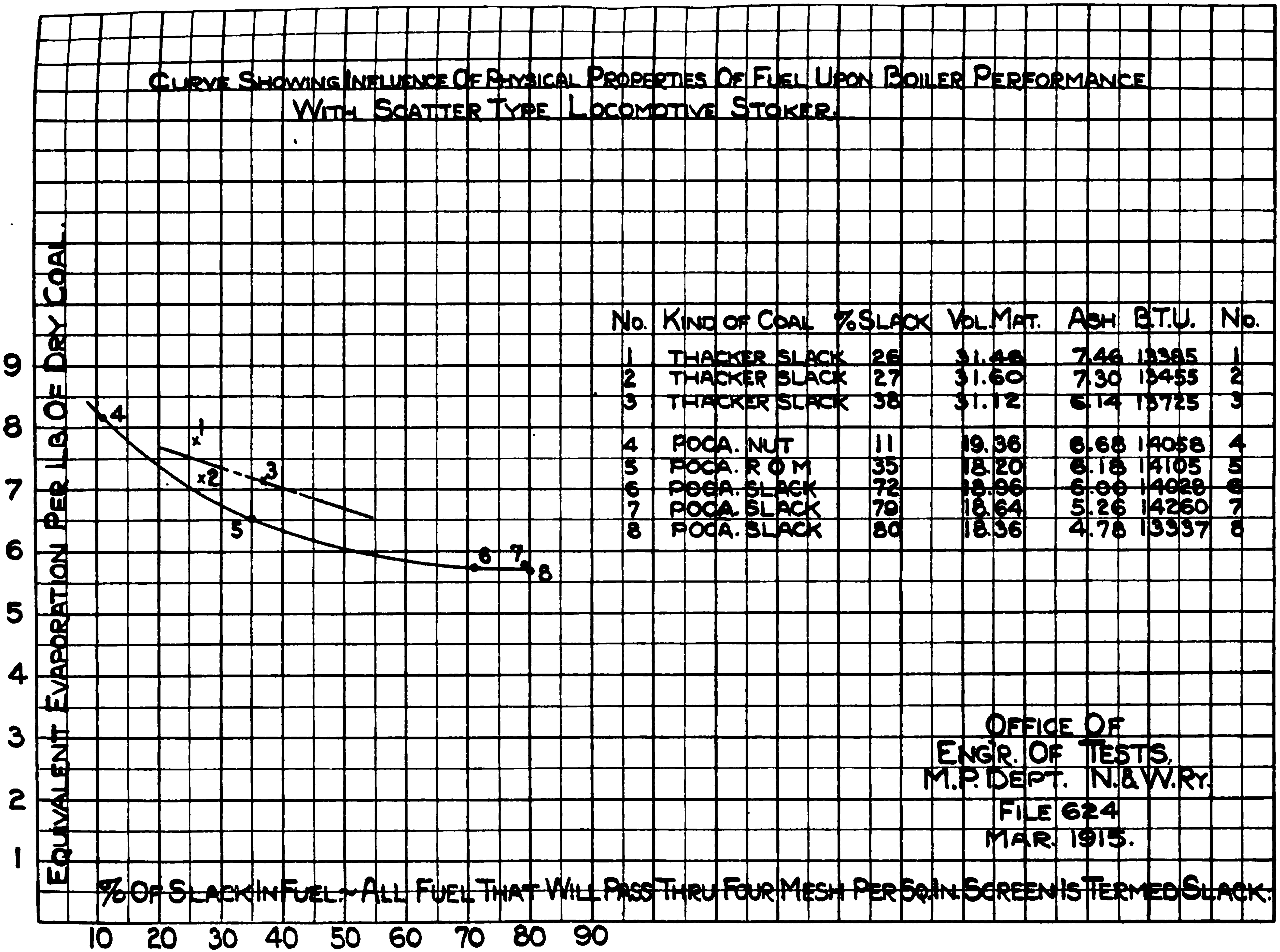
OVERFEED OR SCATTER TYPE.

The Hanna stoker is equipped with durable crushing facilities on the tank, consisting of a heavy helicoid conveyor screw and a bulkhead containing a restricted opening, partly encircled by two stationary knives. Coal is forced through the restricted opening in the bulkhead by the revolving conveyor screw, assisted by the two stationary knives for breaking the larger lumps. This stoker handles slack as well as run-of-mine coal quite efficiently, regardless of weather conditions and moisture of the fuel. In the past year eighteen Hanna stokers have been in continuous operation on sixteen Mallet engines, one Mastodon and one passenger engine. Up to the present time there has been no report showing the stoker has failed to supply steam under the severest conditions, when properly operated. In the event of one of the stokers breaking down, it does not necessarily mean a failure, as the stoker is provided with two distinct recourses to be utilized in such emergencies; first, if any part of the tender conveyor becomes inoperative, the conveyor can be thrown out of operation by means of a clutch and the coal can be shoveled into the locomotive hopper through an opening in the deck; secondly, if the entire stoker becomes inoperative, coal can be shoveled to the plate by hand, from which it is driven to any section of the fire box by means of a blasting chamber and distributing plate. With the assistance of the distributing wings, which is a feature of the machine, the use of the fire hook is materially decreased.

Standard Stoker.

OVERFEED.

The Standard stoker is equipped with adequate crushing facilities on the tank, consisting of a durable helicoid conveyor screw and a bulkhead having a restricted opening partly surrounded by fixed center-punches. Coal is forced through the opening in the bulkhead by the revolving conveyor screw, assisted by the stationary center-punches for crushing the larger lumps. The apparatus is so constructed that it will handle moist coal quite satisfactorily. Two of these stokers were in operation prior to our last report, one on the Norfolk & Western, and one on the N. Y. C. However, during the past year twenty Standard stokers have been put in operation; twelve applied to Mastodon engines (4-8-0) on the N. & W. Ry., five to Mallets on the N. Y. C., one to a Mikado on the Chicago Great Western, one on a Mikado on the Monon, and one to a Mikado on the Virginian, making a total of twenty-two in actual service. These stokers are being operated in slow and fast freight service, and are working satisfactorily. As has been previously explained, the stoker is made under the deck of the engine, leaving the deck and boiler head clear. The machine makes very little noise in its operation, has a good



CURVE SHOWING INFLUENCE OF PHYSICAL PROPERTIES OF FUEL UPON BOILER PERFORMANCE
WITH SCATTER TYPE LOCOMOTIVE STOKER.
No. KIND OF COAL %SLACK VOL.MAT. ASH B.T.U. No.
1 THACKER SLACK 26 31.46 7.46 13385 1
2 THACKER SLACK 27 31.60 7.30 13455 2
3 THACKER SLACK 38 31.12 6.14 13725 3
4 POCA. NUT 11 19.36 6.68 14058 4
5 POCA. R O M 35 18.20 6.18 14105 5
6 POCA. SLACK 72 18.96 6.00 14028 6
7 POCA. SLACK 79 18.64 5.26 14260 7
8 POCA. SLACK 80 18.36 4.78 13337 8
OFFICE OF
ENGR. OF TESTS,
M.P. DEPT. N.&W.RY.
FILE 624
MAR. 1915.
EQUIVALENT EVAPORATION PER LB. OF DRY COAL.
% OF SLACK IN FUEL. – ALL FUEL THAT WILL PASS THRU FOUR MESH PER SQ.IN. SCREEN IS TERMED SLACK.

distributing feature, and is very simple in its control. The latest development of the stoker is the type "AB," which we understand possesses a number of distinct improvements over the type "A" stoker.

Gee Stoker.

OVERFEED OR SCATTER TYPE.

The Gee stoker continues in service on a consolidation locomotive on the Pennsylvania Lines East of Pittsburgh. It is reported that the stoker was put in operation December, 1912, and that it operates satisfactorily. However, it is still undergoing development. Recently slight changes have been made in the control and distributing features.

Kincaid Stoker.

OVERFEED OR SCATTER TYPE.

The Kincaid stoker, which for the past year has been under development on a C. & O. yard engine, continues to progress. The distributing features of this stoker are attached to the fire door. Coal is shoveled into a hopper elevated in front of and attached to the door, from which it gravitates to a distributing apparatus and is delivered to the fire box. It is reported that a conveyor has been worked out and will be applied. After this is done it will be given a service trial on a freight locomotive on the same road.

Elvin Stoker.

OVERFEED OR SHOVEL TYPE.

The Elvin stoker is of rather novel construction, and is the only one that has not substituted some other device or devices for the scoop. Its construction and principle of operation were explained in the committee's last report. A number of stationary tests have been made with the stoker, and it is thought that within the near future the machine will be tested out on a locomotive.

Raite Stoker.

UNDERFEED OR OVERFEED.

The Raite stoker, claimed by the inventor to be either an underfeed or a scatter type, is the only one which your committee has any knowledge of that embodies a combination of the two methods. Mr. George B. Raite, of Indianapolis, advises that this stoker is still being developed and will soon be ready for application. The inventor further claims that special features were recently worked out which should materially improve the distribution of coal and aid combustion.

Ayers Stoker.

CHAIN GRATE.

The Ayers stoker, the sole member of the traveling-grate-type family, reports progress. Last summer and fall a number of experimental trips

were made with this stoker as applied to a N. Y. C. engine, the results of which are reported to be encouraging. During the past winter the stoker has been further developed, and it is thought that it will soon be ready for service.

During the past year your committee has observed the following locomotive stoker patents which were issued to the parties named: G. DeGrahl, R. S. Riley, W. R. Wood, C. D. Young, N. E. Gee, A. G. Elvin, W. C. A. Henry, D. F. Crawford, C. F. Street, W. T. Williams, H. L. Williams, F. S. Forsdick, F. M. Underwood, P. M. Thayer.

It will be recalled several of these patents cover locomotive stokers now in active service, or improvements therein.

Within the past year your committee has been unable to learn of any further activity in the use of the following stokers: Barnum, Dickerson, Heyden, Heyden-Modified, Erie, McMullen, Harvey, Strouse.

Stokers under development not yet applied: Elvin, Raite, Dunning.

Stokers for which no advice can be obtained as to their status: Barnum, Dickerson, Erie, Heyden, Heyden-Modified, Harvey, Strouse.

	Stokers in Active Service.	Stokers on Order.
Street	548	35
Crawford	301	31
Hanna	18	6
Standard	28	92
Gee	1	0
Ayers	1	0
Kincaid	1	0

It is fair to say your committee has not been able to secure data showing any particular difference in the relative consumption of fuel as between the prominent types of scatter-feed stokers. While they are quite similar in design, as shown in previous reports and descriptive literature, the fuel as it enters the fire box in each has been prepared to about the same degree, whether crushed on the engine or before it is loaded on the tender.

With the Street the fuel is delivered to three points of entrance through the back head of the boiler above the fire door; the Hanna delivers fuel to its distributing apparatus in the fire door proper, while the Standard elevates its feed by means of a vertical screw located just inside of the fire door to a point about on a level with the fire door. They are all three of the scatter type and each employs the steam jet in the distribution of its fuel.

Suggestion was made by one of the committees of the Fuel Association with reference to conducting a complete test on one of the University plants, carrying the test through the various grades of fuel and conditions

of operation. Such a test, however, it seems could not be arranged; nevertheless it would have been very interesting and probably set at rest many opinions as to the relative consumption of fuel with different grades of coal. It is to be hoped that such a test will be made possible.

Records have been taken during the past year with the scatter-type stoker in road service, and among others, observations were made on the Norfolk & Western Railway, with a 4-8-0 locomotive known as their class "M-2" type. The locomotive has 24 in. by 30 in. cylinders, and carries 200 lb. steam pressure, having a tractive effort of 52,457 lb. The performance was observed over a district of twenty-nine miles, between Roanoke, Va., and Christiansburg, Va. Seventeen miles of this district is an undulating grade, where the locomotive operated under moderately high-speed conditions, while the remaining twelve miles is an almost uniform grade of 1.32 per cent.

Analyzing the results relating to fuel consumption, it was apparent that the amount of coal consumed varied according to its physical characteristics. The significance of the effect of the physical properties of the fuel stoker fired is shown in curves on sheet attached, representing the relation between equivalent evaporation per pound of dry coal and the proportion of physically fine product in the fuel. The evaporative values of the coal varying inversely with the amount of the slack content. By the latter is meant the amount of fuel that passed through a 4-mesh-per-square-inch screen. The broken line represents the conditions observed, using Thacker high volatile coal, while the solid line refers to the performance with different commercial grades of Pocahontas fuel, which has a low volatile content. It will be observed from the table on the same sheet giving the analysis of the different fuels considered that the variation in fuel consumption were scarcely influenced by the difference in the quality of the fuel, except as it varied in physical properties.

Among the Pocahontas fuels the grade of nut which contained eleven per cent slack gave an equivalent evaporation of 8.2 lb. of water per pound of dry coal, while for the Pocahontas slack, of practically the same heat value, but where the percentage of slack was about eighty, the equivalent evaporation was only 5.6 lb. of water per pound of dry coal. Since these varying conditions of consumption were obtained while hauling the same identical train, with no change made in the drafting or any other feature of the locomotive, it was concluded that the fuel consumption increased rapidly with coal containing a higher percentage of the finer product, on account of a large percentage of the latter being carried through the flues and out through the stack before being completely consumed.

It is not uncommon to find a wide range in the character of coals, not only physically but chemically as well. Take as an illustration the coal from two adjoining territories, the Pocahontas and Thacker fields. The Pocahontas coal is low in volatile, running about 18 per cent, with the heating value ranging from 13,600 to 14,500 B. t. u., while in the Thacker field the volatile is much higher, averaging about 33 per cent,

the heating value ranging from 13,000 to 14,000 B. t. u. Aside from the wide variation in the heat values, it must be admitted that the consumption is vastly affected by the physical characteristics of the coal and the mineral constituents of the ash. To illustrate: The ordinary proximate analysis of a coal shows a certain percentage of ash, and a further mineral examination gives us the component parts, but so far we have been unable to interpret these results in such a manner as to indicate the extent to which the ash will fuse or slag into the grate bars and thus seriously interfere with the combustion of the coal. Some progress has been made in the study of the fusibility of the ash from coals mined in various fields, but here again we find the wide variation in the composition of the ash, even in the output of a single field, adds confusion. It is claimed by some that sulphur has an important bearing upon the fusibility of ash, by others, that high iron and high lime will decrease fusibility. For a concrete example: It was found in some runs made on the Alleghany mountain in heavy freight service that coals running as high as 26 per cent in ash gave a better performance than coals containing but 8.5 per cent ash. There is a distinct difference in the ash; the first, it was concluded, was high in lime and low in iron, enabling it to be readily carried off, while the fuel containing one-third the ash carried a silica constituent which resulted in cementing the ash and particles of unconsumed coal to such an extent as to seriously affect the efficiency of the locomotive. However, this is purely an assumption.

In conclusion it seems safe to say that the mechanical stoker has demonstrated by extensive service that it is capable of supplying coal to a locomotive fire box at a rate and under sufficient control to satisfactorily maintain the working steam pressure. It is also obvious, being a machine and working continuously, it should be capable of maintaining a more regular rate of steaming with certain grades of fuel than might be obtained in average hand-firing practice. The average steam pressure for a division run seems to be in favor of the stoker on account of the higher average pressure maintained, especially toward the end of the run. It may be said, therefore, that greater work is done with the stoker, in terms of speed or tonnage, or both, under certain physical and operating conditions, while in another service with equally large engines and heavy tonnage, but under more favorable grade line and fuel conditions, as high efficiency has been obtained hand-firing. It is also evident that the stoker, since it is a mechanical device, is only limited in capacity by its allowable dimensions, and its endurance should be that of machinery dependent upon design and attention.

As interesting as it would be to define the relation between hand and stoker firing, it is as difficult of determination as the fixing of the rate of efficiency for hand-firing. Many observations have been made and the range of possibility has been fairly well determined, but as can be appreciated, the enormous variable introduced by fuel and physical conditions makes the problem very complex.

To illustrate: Assume a favorable grade of run-of-mine Pocahontas coal containing not less than 50 per cent lump is used for hand-firing, as against the best and most favorable character of fuel for the scatter-type stoker, which would be a nut or pea grade having the lowest percentage of slack or finely divided product. In such a comparison the evaporation would probably be about the same. If now the same grade of run-of-mine coal is retained for hand-firing and in comparison we use the same coal with the stoker, crushing it on the locomotive, we might expect to find a difference of probably ten per cent in evaporative efficiency in favor of hand-firing. If again we continue the use of the same run-of-mine fuel for hand-firing, but use slack on the stoker engine, we might expect to find the evaporative efficiency falling off rapidly and about in proportion to the added fine product in the fuel. In the latter case, however, we are dealing with a fuel (stoker firing) that could scarcely be successfully hand-fired under average conditions.

In conclusion, your committee feels itself unable to point to any rule in terms of weight of engine or train load, or general conditions, where the stoker will always be applicable or necessary, on account of the wide range of physical and operating conditions, as well as character of fuel it fires. The question of fuel is by no means a minor feature, for the reason that the choice of available coals demands consideration of their character as well as price, as the net result of using some of the finely divided grades of stoker-prepared or mixed coal may be offset by a more attractive rate of consumption, better evaporation, and lower cost per ton-mile with run-of-mine, even after it has been crushed to the desired grade.

A. Kearney, Chairman,
M. A. Kinney,
T. R. Cook,
J. W. Cyr,
A. J. Fries,
J. T. Carroll,
J. R. Gould,
Committee.

Mr. Kearney: Before concluding, I think it will be of interest to state that the tabulation on page 8 shows that there are in active service as of June 1 of this year 888 locomotive stokers. For the same period last year there were 728 in active service, which represents an increase of 22 per cent in the past year.

On page 10 of the report, reference, as you will recall, was made to the fusibility of ash, which is a subject of no little interest to those who are studying this general problem. A very interesting article was recently issued by the Bureau of Mines, dealing with the subject quite exhaustively. If my memory serves

me it was their bulletin No. 51; at all events it is a recent publication. In their paper, should any of you wish to look it up, you will find they speak of the clinkering of coal as well as the fusibility of ash found in certain high volatile products where the fuel is delivered to the bed of the fire in large quantities, as against scattering it over the fire surface. You will also find very interesting reading in an article recently published by the American Society of Mechanical Engineers, dealing with the question of temperatures in the fire box under which certain conditions take place.

On page 11 some reference is made to the damage sustained by coal which is handled through stoker crushing machinery. You will observe we speak of run of mine coal being handled through the stoker as compared with the same grade of coal hand fired. Obviously additional crushing of any fuel as it passes through the helicoid screw or what not, changes its physical value, and herein lies a knotty question to solve. Some coals will pack while others have different characteristics. The changing of the physical value affects the rate of consumption, as given some idea of in the chart which is made a part of the report.

That is about all I have to add to our report, Mr. President, except it has occurred to your committee that since the locomotive stokers have apparently developed sufficiently in the past few years to demonstrate beyond a doubt that they are of practical value, it may be your pleasure to dismiss the committee. In the past reports your committee has endeavored to cover the subject as best they could by keeping a memorandum of the various designs worked out, the number in service, at the same time endeavoring to collect all the data possible with reference to their operation, and it has occurred to us that we have gone about as far as we can unless it would be your desire that we attempt to make a complete test on a plant similar to those now in service at one of the universities. Still, even that would be tedious, long-drawn-out and possibly expensive, taking perhaps more time than many of us might have to devote to a line of investigation, which when completed would carry so many limitations, and after all a laboratory test would not completely reproduce what we find in road service.

THE VICE-PRESIDENT: Gentlemen, the report of the Stoker Committee is before you and open for discussion. We would like to hear from representatives of the railroads who have had the most extended experience with stokers, in order that this paper and the discussion may be as complete as possible for the proceedings.

MR. HAYES: I do not desire to open the discussion on the stoker question. I desire to leave that to those who have had more experience than your humble servant; but I would like to ask the chairman of the Stoker Committee, or anybody having had experience sufficient to justify a conclusion on the subject, if they have ever given attention to the question of the relative difference of the stokers and their value to the roads to which they are assigned; that is, the ratio and proportion of the stoker applications, the value of a stoker in dollars and cents, and then its value to the railroad company based upon those figures. If that is not quite plain I will simply ask: If a stoker cost $2,000 or $2,500 and was applied to a locomotive on any railroad, and another stoker of probably very nearly the same design could be applied for say $1,200, or $1,250, or $1,500, and another stoker of about perhaps the same design could be applied for $1,000 or $800 — and then we will go a little bit further and say that perhaps the stoker costing the least amount would give equally as good service, and would fire with equal efficiency the different grades of fuel; has the chairman given consideration to the relative cost of them along those lines? I would be glad to hear it for my own information, and perhaps there are others who would like to hear the same thing.

THE VICE-PRESIDENT: Mr. Chairman, I suggest if you have any costs that you call them A, B, C, D, E, and if the gentleman wishes any more definite information he can get it off the floor of the convention.

MR. KEARNEY: Gentlemen, in order to obtain the figures mentioned by Mr. Hayes we would probably first have to determine how far we would be justified in spending money for a stoker, making a comparison or taking as our basis whatever might be determined as economical from hand firing. I should say,

however, there would probably be found many difficulties in the way of determining the economical line on account of the almost countless variables, aside from the widely differing grades of coal and physical conditions. As for the price of the stoker and cost of application, I am sure they are known to most of us, or can be readily ascertained. The question, however, is susceptible to solution, but is one that must be worked out by each road contemplating the use of the stoker, after taking into consideration all of the conditions surrounding their use. I have no doubt if the gentlemen you referred to a while ago as an Efficiency Engineer is in the room he may be able to tell us how much money we would be warranted in spending on a locomotive or stoker, or may be able to tell us the location of the economical line. If we are furnished with that information we will be better able to say how close we are to it or how far we have yet to go before it is crossed. The work of the stoker inventors, designers and manufacturers has been to get a machine to automatically handle fuel at a rate and in sufficient quantity to satisfactorily fire a locomotive under the conditions met in service, and that we think has been accomplished.

While I have no doubt we are ready to admit that the stoker has passed the experimental stage, it is well known that the manufacturers are still redesigning and experimenting for further improvements; not perhaps so much in the results obtained in the firing process, but in simplifying and making even more durable the machinery they now utilize. Hence, to attempt to settle upon any figure at this time as representing what the stokers will cost for maintenance will hardly be fair, but if Mr. Hayes will point out the line of economy it will help the railroads and manufacturers to locate themselves.

Mr. L. R. Pomeroy: Mr. Chairman, I believe it has been conceded that with the modern type of locomotive the design is based on evaporating ten pounds of water per square foot of heating surface. That being so, and it is also suggested as a conservative rating, a locomotive with from 4,500 to 5,000 square feet of heating surface would require over 8,000 pounds of coal per hour. I would like to ask for information from those who are discussing the subject from a practical point of view, if

they could give us any information as to the total amount of coal per hour it is possible for the stoker to handle. If it established that they could easily handle 8,500 pounds of coal per hour, and the ordinary fireman can only handle 4,500 pounds, the difference in gain between 4,500 pounds of coal and 8,500 pounds of coal ought to be a measure by which you could compare and rate the economy and value of the stoker.

MR. KEARNEY: I should say we have quite doubled the figure in quantity of coal delivered to the fire box per hour.

THE VICE-PRESIDENT: Seventeen thousand pounds?

MR. KEARNEY: Not quite, I should say, but in that neighborhood. I think Mr. Pomeroy need have no fear, as it is simply a question of design and dimensions or latitude permitted for the construction of the stoker and its working parts. Indeed we have had this figure to run up over 12,000 pounds per hour.

MR. MACBAIN: Mr. Chairman, it seems to me that the question of inquiry into the initial cost of the stoker is something that we could very well let stand at the present time, and let every person who is in the stoker business go ahead and develop his stoker to the full extent of his ability. The stories that I hear of the stoker, and from my own personal experience as far as I have had any, which is very little, are to the effect that the mechanical stoker will increase the hauling capacity of the large locomotive, on such as they are installed, anywhere from 250 to 500 tons over what can be hauled with a fireman, and it seems to me that when you get into figures of that kind, that a few hundred dollars in the initial cost of the stoker applied to the locomotive might very consistently be lost sight of for the time being while the development is going on.

MR. J. H. MANNING (D. & H. Co.): I would like to inquire from Mr. Kearney if the observations of the committee were with the brick arch or without, and if there was anything developed in the way of increased maintenance of flues and fire boxes?

MR. KEARNEY: The locomotive referred to was equipped with brick arches; in fact all of the engines equipped with the stoker have the brick arches. There was no trouble or difference experienced.

Mr. W. C. A. Henry (Pennsylvania Lines): The Pennsylvania Lines west of Pittsburgh within the last month have ordered fifty consolidation locomotives having a tractive power of 53,000 pounds. They are all to be equipped with the Crawford stoker. We have decided to do that because our experience has been that with these locomotives on a level division, where the average fireman is worked to his capacity, the stoker enables us to get about eight to ten per cent more ton miles per hour on the road, which makes it an attractive proposition.

Reference has been made to brick arches. None of these locomotives have them. Our passenger locomotives, however, where the fire box is deep enough to permit it, have arches.

In the body of the report reference has been made to a reversing mechanism for the stoker. We have found such device to be very necessary, and all are being equipped with a very simple mechanism, by which the direction of the travel of the piston can be reversed at any time.

As regards the preparation of the coal, there is no special preparation required as we simply use run of mine coal. The conveying mechanism, however, is so constructed that a lump of coal too large to be handled through the conveyor will be broken to usable size by the crusher before entering the conveyor mechanism.

Mr. M. K. Barnum (B. & O. R. R.): Mr. Chairman, I have not any data showing the increased tonnage, but our stoker locomotives in tests made some time ago showed an increase over hand-fired engines of the same design which I believe was somewhat in excess of 5 per cent. They also made about 20 per cent greater average speed than the hand-fired locomotives.

Stoker failures are very rare. From memory, I should say that with about 223 stokers we are not having to exceed one or two failures a month, and those are of minor importance. We are getting excellent results from our power and are operating some 2-10-2 locomotives with the stoker, which are larger than we could operate successfully by hand firing.

Mr. W. E. Symons: In connection with the item of the relative cost of the stokers, it has occurred to me to be not improper to suggest that the cost of a stoker at present might

properly be compared with the salary of an additional fireman, which would be necessary on the large type of locomotives in order to work them to their capacity with hand firing. I believe that about six thousand pounds of coal, or three tons per hour, is about the physical capacity of the ordinary fireman. Some years ago when our first mechanical stokers were brought out, the railway managements were confronted with a demand for additional firemen on locomotives, particularly the large engines. This demand has been persistently followed up, and managements were confronted with the fact that they would either have to provide some means of firing these engines to their capacity with a power stoker or an additional fireman. The motive-power officers have taken the matter in hand and are working it out very nicely. While all the various stokers at different prices are not entirely out of the experimental field, I think they have progressed so well that the seal of approval should be given to the work done as one of progress, and that any comparison in prices should be as between the price of a stoker and the salary of an additional fireman, rather than from any other standpoint, as a power stoker is practically essential to the full working capacity of large engines regardless of the price.

THE VICE-PRESIDENT: We have representatives of several of the stoker manufacturers in the room, and if there are no objections, the privilege of the floor will be given them for a limited time. Mr. Street.

MR. C. F. STREET: Mr. Chairman and Gentlemen: To my mind the one important feature, as I have said in these conventions a number of times, in dealing with the locomotive stoker is increased capacity; and all these other features sink into insignificance when compared with it.

We hear a great deal of talk at this convention and of course at other conventions of this nature, about the saving of fuel. As I have said before, I believe I am the only man who has the distinction of having placed a device on the market for locomotives who did not claim that it would save fuel. I have never claimed that the locomotive stoker would save fuel. On the other hand, there are a great many devices which are put on the

locomotives which will save fuel, but are being used as capacity-increasers instead of fuel-savers.

You talk about the saving accomplished by the use of the brick arch. The brick arch will save fuel, but it will increase capacity. The same is true about the superheater. You talk about saving fuel with the superheater. I have noticed that every locomotive, or practically every locomotive, that is equipped with the superheater is hauling more tonnage, and it is burning the same amount of coal it burned before the superheater was put on. The superheater is first and essentially a capacity-increaser in actual service. Theoretically it is also a fuel-saver. Your stoker is essentially a capacity-increaser. I do not believe there is a single locomotive running in this country to-day, equipped with stokers, which locomotive is not hauling a greater tonnage at the same speed or a higher tonnage at a higher speed than the same locomotive hand fired. Here is the field of the stoker, and all other things sink into insignificance in comparison with it.

There is one other feature, of course, and that is that the stoker has made possible the building of locomotives which could not be run without stokers. I think none of the 2-10-2 type of locomotive, which has been introduced within the last year, and which was referred to by your President in his address, would ever have been built, had it not been known that a stoker could be secured for firing.

This increased tonnage possible with these larger locomotive is best illustrated by a remark made by Mr. A. C. Willsie, of the Chicago, Burlington & Quincy, at the recent convention of the International Fuel Association held at Chicago, where Mr. Willsie made a statement that the 2-10-2 type of locomotive, stoker fired, will haul 1,483 more tons than with a hand-fired Mikado, and that is a Mikado having 60,000 pounds tractive power.

I said I do not claim the stoker is not a fuel-saver, but Mr. Willsie said the cost of coal per ten thousand ton miles with the 2-10-2 locomotive is 34 cents, as against 45 cents for the Mikado, hand fired. There is a decrease which is really worth going after in the fuel bills, per thousand ton miles put over the road.

There are several things in this report to which I would like

to refer. What the committee says regarding the reversible engine is absolutely true, but that same thing can be accomplished in other ways rather than by a reversible engine. The stoker mechanism must be such that it can be reversed by some means, and if not by a reversible engine some equally efficient device must be provided.

Regarding the question of maintenance, we have been aiming at 50 cents per hundred miles, and this varies in accordance with the manner in which your records are kept. Some roads keep records which include the cost of inspection in the cost of maintenance, and some would ignore that.

The same thing is true with regard to failures. I can not help think that the miles run per failure of 1,000 to 5,000 is pretty low. A master mechanic made a statement to me the other day that he had 150 stoker locomotives under his care — this was about three weeks ago — and he said he had not received a report of a stoker failure since the first of January. I said, "Do you not think there have been some?" He said, "probably there have, but they have not been of sufficient importance to come to my notice."

I had a report recently from a Superintendent of Motive Power, saying that his five stoker-fired locomotives had made 90,000 miles without a record of stoker failure. It just depends on what you call a stoker failure. It has been put up to me that the clogging of a distributor was a stoker failure. You might as well say that the bending of a shovel was a shovel failure, because neither has any effect on the efficiency of the locomotive or on the service it gives.

This question of the physical characteristics of the coal, which the committee has brought out, is a very interesting one, and one on which we secured some interesting data within the past year and only quite recently. This report gives a curve which shows that the rate of fuel consumed, the water evaporated, varies in proportion to the amount of slack in the fuel. That is absolutely true, but only to a rate of burning of from sixty to seventy pounds of coal per square foot of grate and above. The water-evaporated per pound of coal up to that point is not affected materially by the amount of slack in the coal, but

when you get up to burning one hundred or one hundred and twenty to one hundred and fifty pounds of coal per square foot of grate, the efficiency falls off in proportion to the amount of slack in the coal; and exactly the same thing is true in hand firing. I think you all have observed that the figures run almost identically the same for hand firing as they do for stoker firing. I have seen reports of tests where there was an increase in the coal consumption of 20 per cent, owing only and absolutely to the amount of slack there was in the coal used for hand firing. The difference probably is about the same with stoker firing, but only at the high rates of burning.

There is another feature which enters in there: with the stoker there is no danger of a steam failure, no matter how high a rate of burning is used; while with hand firing, when you get above a certain proportion of slack in the coal, it is impossible to maintain steam pressure. I think you have all observed that.

A great many of you have had reports of poor coal on locomotives and found that the chemical analysis of that coal was very good, but a large percentage of slack has resulted in the locomotive failing for steam. With the stoker it makes no difference how much slack there is in your coal, in fact, you can stoke a fire and maintain steam pressure with coal that has no lumps in it at all, but of course it will take a larger amount of this coal to produce results equal to those secured with coal containing lumps.

Another feature which is important, in the development of the stokers, is the ability to use a much lower grade of fuel. This condition obtains in the West more than in the East. The western coal mines have a large quantity of slack with which it is impossible to maintain steam pressure hand fired, but the stoker is successfully using this slack; the C. B. & Q. R. R. is doing that; and that is one of the reasons for this large saving in cost of fuel which was noted by Mr. Willsie. The slack I think costs about 80 cents per ton, compared with $1.20 per ton for run of mine coal used for hand firing.

I have seen 15,500 pounds of coal put through a stoker in an hour, but under such conditions that the locomotive did not burn it economically. The coal was put into the fire box to see how

much could be put through the stoker. I think there are records of 17,000 pounds, but I have never seen them.

I do not think of anything else that I would say except that I wish to come back to the important point of increased tonnage. I would not say that under all conditions on large locomotives, that the application of a stoker would enable increased tonnage. There are undoubtedly conditions under which large locomotives are working at slow speeds, where you are satisfied with slow speeds, where the stoker will not give you any marked increase in tonnage. Any of these large locomotives running at 4, 5 or 6 miles per hour can be worked to their full capacity by hand firing; but when you get up a speed to 10, 15 or 20 miles an hour, no man living can hand fire them. Along that line one very important development has recently been made where locomotives stoker fired are doubling a 100-mile division in fourteen hours. The average speed which a stoker can maintain is so much greater than is possible to maintain with hand firing, that this result has been obtained. That of course goes right along with the increased tonnage.

The important feature is increased tonnage and increased average speed of heavy freight trains. That is what the stoker has actually accomplished. [Applause.]

Mr. Kearney: I would like to say that the figures given by Mr. Street I know to be correct. I had the opportunity of witnessing some runs, observing that at one period the stoker was delivering coal to the fire box at the rate of approximately 15,000 pounds per hour. When you asked me this question a few moments ago you will recall I simply answered in round figures.

With reference to Mr. Street's remarks about the miles run per failure: In our report showing this mileage we give it as ranging between 1000 and 2500, which is absolutely correct, and they are results taken from a great many months' service. They are, however, obtained from the engine crew, and a very critical search of the performance sheet. Last year we calculated the miles run from the dispatcher's sheet, which we have since concluded did not give us complete information for our purpose. If we had taken the same base of calculation this year as we did last the mileage would be about four times as much

as we now show in the report. It is quite well appreciated that a minor failure can occur on the road which, while quite easily repaired by the crew without necessarily delaying the train, would be a failure of a part we would like to know for a complete report. Such failures can occur on the road without disturbing the traffic, and would, therefore, be of no particular interest to the dispatcher. We include all failures in our report since we view them from another angle, being desirous to know all defects and shortcomings so that further study can be given each detail part for higher efficiency.

THE VICE-PRESIDENT: I notice that the Association has been honored by the Interstate Commerce Commission in sending a representative here. If there are no objections it will be ordered that Mr. McManamy, Chief of the Federal Boiler Inspection Bureau, be given the privilege of the floor at any time during the convention. Mr. McManamy is very modest; he is sitting in the rear row.

MR. W. J. TOLLERTON (C. R. I. & P. Ry.): I should like to make a motion that Mr. McManamy be accorded the privilege of the floor.

THE VICE-PRESIDENT: Then if there are no objections Mr. McManamy may have the floor at any time.

MR. MCMANAMY: I simply want to thank the Association for the courtesy, and say that I will try not to abuse the privilege. [Applause.]

THE VICE-PRESIDENT: Are there any further remarks on the stoker paper?

MR. MACBAIN: I wanted to make a few remarks about the opportunity the stoker has been given sometimes to perform its function. About two years ago the road I am connected with purchased three very large Mallet type of engines for pushing up coke and ore. I was at Ashtabula one night when they were shoving some up, and there was a pusher engine which was apparently being pulled by the cars. There was nothing but a straight column of steam going out of the stack to a height of about 125 feet, with no intermittent exhaust. It was just one series of roars. That did not look very good, and I took the

matter up with Master Mechanic Franey and asked him to measure up the size of the stack of one of these engines. He sent in the information that it had a stack which was nineteen inches in the choke, and the nozzle was correspondingly small in order to make up for the difficulty in getting the exhaust steam out through that small stack. That locomotive was designed by the best talent we have in the United States, and it ran about six or eight months before this condition was noticed. We took the engine into the shops and Mr. Franey increased the stack from nineteen inches at the choke to twenty-five, and the other openings accordingly. It was astonishing the things that he found; all the blows known to the art were concealed in there by this roar of steam that was coming out at the front end. Everything in there was in bad order. Our fuel consumption was all that could be desired from the point of the coal dealer. After Mr. Franey enlarged the stack and nozzle so that the excess could be got rid of, the fuel consumption of the engine, it is fair to say, was reduced 25 per cent. That is not attributable to the stoker, but it is attributable to the poor condition in which the engine was before it was given a fair show, so to speak; and I am just wondering if there are many Mallet engines around the country in the same condition.

There was a condition where it was impossible for any engineman to tell what was wrong with his engine, or whether anything was wrong with it or not. It was pushing the cars all right, taking the place of two standard Consolidation engines, but it was laboring under a great disadvantage in not having been kept in proper repair, and that was true because we did not know that there was anything wrong with it.

I would suggest to the men who are operating Mallets, and other very large units of freight power, that that matter be given a considerable amount of attention.

The President resumed the chair at this point.

THE PRESIDENT: We have not heard from the Hanna or the Standard Stoker Companies. If they are represented, unless there is some objection, I would like to hear from them.

MR. E. A. AVERILL (Standard Stoker Co.): There are two or three things in the report to which I would like to call atten-

tion, but first I would like to emphasize what Mr. Street has said in connection with the stoker on locomotives, which is primarily a matter of increased power or the opportunity given to use the power which you have in the locomotive.

In connection also with Mr. Hayes' question I might mention that in one case where tests were made, carefully conducted tests, it developed that the application of stokers on that particular division, to those particular engines, would result in saving approximately $100 per engine per month. That was very largely due to increased tonnage, and partially due to the elimination of the second fireman during the hot months.

I would like to ask Mr. Kearney if the percentage of slack in both of these tests was the percentage of the coal, as put on the tender or the percentage of the coal as fed to the fire box.

MR. KEARNEY: On the tender.

MR. AVERILL: That was the coal as fed to the tender. We make no tests in connection with the hand firing with the same detail and on the same relation?

MR. KEARNEY: No, sir.

MR. AVERILL: Quite probably the curve would follow somewhat the same shape in hand firing, but as to the exact location it would depend on the character of the fuel under test.

You mentioned in the third paragraph, on page 11, that "If now the same grade of run-of-mine coal is retained for hand firing, and in comparison we use the same coal with the stoker, crushing it on the locomotive, we might expect to find a difference of probably 10 per cent in evaporated efficiency in favor of hand firing." In such tests as I have made, and have assisted in making, I have not found that to be true. It may be true, of course, in some cases, but the tests I have been on and several others have shown under those conditions mentioned, using the same coal, and crushing it on the tender, the stoker does not use any more coal hand firing, and on another test it ran as high as 7 or 8 per cent in favor of the stoker in equivalent evaporation per pound of dry coal. These deductions were gained from two separate tests. These tests indicate that the conditions in arranging for the test were such that the stoker was not extravagant

in fuel, and did not use any more fuel than in hand firing. In the case where it was given the opportunity of developing the full capacity of the locomotive it showed an evaporated efficiency as high as 11 or 12 per cent on the same basis.

The report makes mention on page 3 of the result of a much thinner bed of fire being carried than economy required. That, I assume, means economy of the locomotive and not economy of combustion. I can not conceive of a condition where two thin a fire could be carried, if you are going to get the best results from the burning of the fuel, if you are going to get the largest amount of heat out of the fuel. If you are going to carry such a fire and have the spots open, you will waste heat. As far as burning coal is concerned, you will get more heat from the thinner fire.

MR. KEARNEY: Mr. Averill raises two questions: one the comparison between run-of-mine coal and the same grade of coal handled through the crusher; and the other, the thickness of the fire. It should be understood that in our tests we used the Pocahontas and Wacker run-of-mine and prepared fuels. I think it would be well to remember that there is a vast difference between the Pocahontas high volatile coal and many of the other products. You will recall we made particular mention of this in the report, stating in substance that where we get into other fields we find entirely different conditions from those obtaining with the use of Pocohontas coal.

As for the thin fire, it will be recalled by those who have been more closely associated with the earlier stoker experiments that the watchword was to carry a thin fire. As a matter of fact the fires were so thin it was difficult to keep sufficient on the grates, but experience soon taught us that it was economy to carry a moderate fire, though much thinner than for good work hand firing.

MR. AVERILL: In mentioning these figures of saving, I stated clearly the result of conditions which existed on these particular tests, not making that as a broad statement.

MR. KEARNEY: I understand, but I think it would be well to remember that my remarks referred to observations made while using Pocahontas coal.

Dr. Angus Sinclair: The suggestion has been made that this committee be dismissed, which I think would be quite a mistake. At any rate, if this one is dismissed another one should be appointed to take its place, for I consider that the subject is one of the most important before the railway companies to-day, and it is the duty of the American Railway Master Mechanics' Association to make the best possible headway they can on this subject. I think the importance of saving fuel on a railroad is second to none in connection with the operation of a locomotive, and from a practical standpoint, so far as the stoker is concerned, it is certainly an advance over hand firing.

Quite a number of years ago when the first automatic mechanical stokers came out I felt interested enough in the stoker to go and investigate it as closely as I could, and I had the privilege of riding for five or six trips on a locomotive equipped with a mechanical stoker. I had had experience with a great many devices applied to locomotives, some successful and others unsuccessful, and my impression was that this stoker was as efficient as anything brought out as an improvement in locomotive operation, although it required some changes that could easily have been carried out had there been zeal to push them into effect. There was some trouble with the conveyor, which was rather defective but which certainly was capable of improvement, and because the conveyor failed occasionally this stoker was declared to be no good.

Now, that was the case where persistence would have overcome the whole difficulty, but the stoker dropped out of use in a few months without having had the opportunity to do what it might have done, and I think where an economy of fuel is desired that the stoker is the right thing. I believe the railway companies that are doing their best to make the stoker operative are those that are going to do their work with the least expenditure of fuel.

The President: Replying to Mr. Sinclair, I think the whole subject should have been left open to the incoming Executive Committee. It is possible that the Executive Committee may make changes in the personnel of this committee, but I think a committee of this kind should be continued. I know that the

present committee has done a great deal of very hard work, but it is possible that some changes might be made in the membership of the committee and the committee could continue its work. I still think the committee should be continued, and it might be a wise thing to leave the matter to the Executive Committee to determine.

We have not heard any one in this discussion who represents the Hanna stoker. Is there anybody here who would like to speak of that stoker?

Mr. Leclanche Moen (C. W. Hunt Co., Inc.): I regret to state that Mr. W. T. Hanna is not present this morning, but I hope he will be here for a part of this week. I am the President of the C. W. Hunt Company, and I am speaking in behalf of the Hanna Locomotive Stoker Co., because the Hunt Company expects to undertake the manufacture of the Hanna stokers. As I say, I am sorry that Mr. Hanna is not here to speak of the stoker, and I do not feel myself personally qualified to do so. However, I do want to say to the convention that the C. W. Hunt Company is prepared to manufacture the Hanna stoker and is going to secure some business for these stokers. I would like to say in substantiation of the remarks of the President that it would seem to me a great pity if the Committee on Stokers were dismissed and the work abandoned at this time. In my opinion there is a great deal of work yet to be done in which this committee could be of very valuable assistance.

The President: As our time for this report has long gone by, we will close it and go on with the next subject.

The Secretary: The President in his address this morning made references to some matters of importance, among them the subject of consolidation with the Master Car Builders' Association, and a suggestion as to the consideration of costs of various commodities, etc. It seems to me we should not lose sight of these recommendations, and I would make a motion that such recommendations as have been referred to by the President, be referred to the incoming Executive Committee for consideration in making up its program for the next meeting.

The motion was duly seconded and carried.

THE PRESIDENT: The next subject which we will consider at this session is the report of the Committee on Revision of Standards and Recommended Practice, Mr. W. E. Dunham, S. M. P. & C., C. & N. W. Ry., is chairman of the committee.

Mr. Dunham presented the report as follows:

REPORT OF COMMITTEE ON REVISION OF STANDARDS AND RECOMMENDED PRACTICE.

To the Members:

After consideration of the present Standards and Recommended Practices of the Association, together with the replies received to the Circular of Inquiry sent to the members, and instructions and other information received from the Executive Committee and from the Secretary of your committee, would submit the following report:

SPECIFICATIONS FOR STEEL AXLES FOR LOCOMOTIVE TENDERS.

(Standard.)

Page 475.

1. Your committee would recommend the revision and modification in form of the present Specifications for Steel Axles for Locomotive Tenders as shown in Appendix A, the requirements agreeing with the Standard of the M. C. B. Association.

JOURNAL BOX, BEARING AND WEDGE.

(Standard and Recommended Practice.)

Pages 478, 479.

2. For journals 3¾ by 7 in. Sheet M. M. 2.
For journals 4¼ by 8 in. Sheet M. M. 5.
For journals 5 by 9 in. Sheet M. M. 8.
For journals 5½ by 10 in. Sheet M. M. 11.
For journals 6 by 11 in. Sheet M. M.—M.

A member suggests that the section of the journal boxes indicated be shown or lettered as AA, BB, CC as shown on Sheet 11.

Your committee concurs in the recommendation and the Secretary is instructed to change the drawings.

3. For journals 3¾ by 7 in. Sheets M. M. 3 and 4.
For journals 4¼ by 8 in. Sheets M. M. 6 and 7.
For journals 5 by 9 in. Sheets M. M. 9 and 10.
For journals 5½ by 10 in. Sheets M. M. 12 and 13.
For journals 6 by 11 in. Sheets M. M. L and N.

A member suggests that the drawings on these sheets show the lining on the journal bearings the same as is shown on Sheets L and N.

Your committee concurs with the further suggestion that a note be added to the detail of the bearing shown on Sheets 4, 7, 10, 13 and N to the effect that "This surface to be tinned before lining is applied." The Secretary is instructed to change these drawings.

4. For journals 5 by 9 in. Sheet M. M. 10.

A member calls attention to the omission of the upward projecting lip on the top of the front edge of the journal bearing wedge.

Your committee notes the omission and the Secretary is instructed to correct the drawing.

5. For journals 6 by 11 in. Sheets M. M. L M and N.

Page 479.

A member suggests advancing these details to Standards from Recommended Practices.

Your committee concurs in the suggestion.

Specification for 33-in. Cast-iron Wheels.

(Recommended Practice.)

Page 482.

6. A member calls attention to the first figure in the table in Paragraph 9, Section V, under the heading Maximum Gross Weight of Tenders, advising that this should be 95,000 instead of 112,000.

Your committee notes the error and the Secretary is instructed to correct the figure.

Specification for Boiler and Fire-box Steel

(Standard.)

Pages 490-492.

7. Your committee would recommend the revision and modification of the present Specifications for Boiler and Fire-box Steel as shown in Appendix B.

Specifications for Locomotive Driving and Engine Truck Axles.

(Standard.)

(Page 499.)

Specifications for Locomotive Forgings.

(Standard.)

Page 500.

8. Your committee would recommend the revision and modification of the present Specifications for Locomotive Driving and Engine Truck Axles

and the present Specifications for Locomotive Forgings and combining them in one, Specifications for Annealed and Unannealed Carbon-steel Axles, Shafts and Other Forgings for Locomotives as shown in Appendix C.

SPECIFICATIONS FOR LOCOMOTIVE CYLINDER CASTINGS, CYLINDER BUSHINGS, CYLINDER HEADS, STEAM CHESTS, VALVE BUSHINGS AND PACKING RINGS.

(Standard.)

Pages 503-504.

9. Your committee would recommend the revision and modification of the present Specifications for Locomotive Castings, Cylinder Bushings, Cylinder Heads, Steam Chests, Valve Bushings and Packing Rings as shown in Appendix D.

SPECIFICATIONS FOR CAST-STEEL LOCOMOTIVE FRAMES.

(Recommended Practice.)

Page 504.

10. Your committee would recommend the revision and modification of the present Specifications for Cast-steel Locomotive Frames substituting for the same the Specifications for Steel Castings for Locomotives, as shown in Appendix E.

INSPECTION AND TESTING OF LOCOMOTIVE BOILERS.

(Standard.)

(Pages 531-538.)

11. To conform to the latest revision in the Federal Regulations for the Inspection and Testing of Locomotive Boilers and their.appurtenances, your committee would recommend the revision of the following paragraphs as shown.

FACTOR OF SAFETY.

2. The lowest factor of safety to be used for locomotive boilers constructed after January 1, 1912, shall be 4.

The lowest factor of safety to be used for locomotive boilers which were in service or under construction prior to January 1, 1912, shall be as follows:

Effective January 1, 1915, the lowest factor shall be 3, except that upon application, this period may be extended not to exceed one year, if an investigation shows that conditions warrant it.

Effective January 1, 1916, the lowest factor shall be 3.25.
Effective January 1, 1917, the lowest factor shall be 3.5.
Effective January 1, 1919, the lowest factor shall be 3.75.
Effective January 1, 1921, the lowest factor shall be 4.

3. MAXIMUM ALLOWABLE STRESS ON STAYS AND BRACES.—For locomotives constructed after January 1, 1915, the maximum allowable stress

per sq. in. of net cross sectional area on fire box and combustion chamber stays shall be 7500 lb. The maximum allowable stress per sq. in. of net cross sectional area on round, rectangular or gusset braces shall be 9000 lb.

For locomotives constructed prior to January 1, 1915, the maximum allowable stress on stays and braces shall meet the requirements of Rule No. 2, except that when a new fire box and wrapper sheet are applied to such locomotives, they shall be made to meet the requirements of Rule No. 3.

STAY BOLT TESTING.

24. Method of Testing Flexible Stay Bolts Without Caps.—Flexible stay bolts which do not have caps shall be tested once each month, the same as rigid bolts.

Each time a hydrostatic test is applied, such stay bolt test shall be made while the boiler is under hydrostatic pressure not less than the allowed working pressure, and proper notation of such test made on Form No. 3.

STEAM GAGES.

29. Siphon.—Every gage shall have a siphon of ample capacity to prevent steam entering the gage. The pipe connection shall enter the boiler direct, and shall be maintained steam-tight between boiler and gage. The siphon pipe and its connections to the boiler must be cleaned each time the gage is tested.

SAFETY VALVES.

35. Setting of Safety Valves.—Safety valves shall be set to pop at pressures not exceeding 6 lb. above the working steam pressure. When setting safety valves, two steam gages shall be used, one of which must be so located that it will be in full view of the person engaged in setting such valves; and if the pressure indicated by the gages varies more than 3 lb. they shall be removed from the boiler, tested and corrected before the safety valves are set. Gages shall in all cases be tested immediately before the safety valves are set or any change made in the setting. When setting safety valves the water level in the boiler shall not be above the highest gage cock.

FILING REPORTS.

52. A copy of the monthly inspection report, Form No. 1, or annual inspection report, Form No. 3, properly filled out, shall be placed under glass in a conspicuous place in the cab of the locomotive, before the boiler inspected is put into service.

54. Specification Card.—A specification card, size 8 by 10½ in., Form No. 4, containing the results of the calculations made in determining the working pressure and other necessary data shall be filed in the office of the chief inspector of locomotive boilers, for each locomotive boiler. A copy shall be filed in the office of the chief mechanical officer having charge of the locomotive. Every specification card shall be verified by the oath of the

engineer making the calculations, and shall be approved by the chief mechanical officer. These specification cards shall be filed as promptly as thorough examination and accurate calculation will permit. Where accurate drawings of boilers are available, the data for specification card, Form No. 4, may be taken from the drawings, and such specification cards must be completed and forwarded prior to July 1, 1912. Where accurate drawings are not available, the required data must be obtained at the first opportunity when general repairs are made, or when flues are removed. Specification cards must be forwarded within one month after examination has been made, and all examinations must be completed and specification cards filed prior to July 1, 1913, flues being removed if necessary to enable the examination to be made before this date.

When any repairs or changes are made which affect the data shown on the specification card, a corrected card or an alteration report on an approved form, size 8 by 10½ in., properly certified to, giving details of such changes shall be filed within 30 days from the date of their completion. This report should cover:

(a) Application of new barrel sheets or domes.

(b) Application of patches to barrels or domes of boilers, or to portion of wrapper sheet of crowbar which is not supported by stay bolts.

(c) Longitudinal seam reinforcements.

(d) Changes in size or number of braces, giving maximum stress.

(e) Initial application of superheaters, arch or water bar tubes, giving number and dimensions of tubes.

(f) Changes in number or capacity of safety valves.

Report of patches should be accompanied by a drawing or blue-print of the patch, showing its location in regard to the center line of boiler, giving all necessary dimensions and showing the nature and location of the defect. Patches previously applied should be reported the first time boiler is stripped to permit an examination.

NEW BUSINESS.

12. Through the Secretary a communication was received advising that the Arbitration Board of the Master Car Builders' Association had been called upon for some rule in the Code to cover the use of brakes on locomotives handled dead in train and offered in interchange. An expression on this subject was requested from the A. R. M. M. Association, the details being referred to this committee. After considerable investigation your committee would recommend the following regulations covering the operation of brakes on engines and tenders handled dead in train and offered in interchange:

1. All engines equipped with side rods must have them applied, when handled dead in trains, suitable washers, of wooden blocks clamped together with bolts, being used where necessary on main rod bearings to keep the side rods in place.

2. All engines and tenders hauled dead in trains must have the air brakes cut in and operative on drivers, trailers and on tender trucks.

3. Engines and tenders equipped with the Westinghouse ET, or New York LT brake must have the safety valve on the distributing valve, or control valve, adjusted to not less than 25 lb. or more than 30 lb.

4. Engines and tenders equipped with the automatic and straight air combined must have the safety valve in brake cylinder pipe adjusted to not less than 25 lb. or more than 30 lb.

5. Engines equipped with Westinghouse ET, or New York LT brakes, or with straight air must have positive stops applied to handles of automatic and independent valves to secure these handles in running position.

6. Engines and tenders equipped with high speed brake without the straight air, must have the high speed reducing valve set to reduce the brake cylinder pressure to not less than 25 lb. or more than 30 lb., or must have a safety valve applied to the brake cylinders or the brake cylinder pipe set to not less than 25 lb. or more than 30 lb.

7. Engines and tenders equipped with only the automatic brake must have a safety valve applied to the brake cylinders or the brake cylinder pipe set to not less than 25 lb. or more than 30 lb.

8. Engines fitted with power brakes other than air must be equipped with an air train line and connections.

9. Delivering line will be held responsible for flat spots on driving tires, trailer tires and tender truck wheels.

10. Owners shall be responsible for any special application of safety valves as required in Sections No. 3 to 8, inclusive.

Recapitulation.

Secretary requested to make alterations or corrections 2, 3, 4, 6.

Referred to Letter Ballot for Changes in Standards or Recommended Practices: 1, 5, 7, 8, 9, 10, 11 and 12.

Respectfully submitted,

W. E. Dunham, Chairman,
A. R. Ayers,
M. H. Haig,
A. G. Trumbull,
C. D. Young,

Committee.

APPENDIX A.

Specifications for Steel Axles for Locomotive Tenders.

I. Manufacture.

1. **PROCESS.**—The steel shall be made by the open-hearth process.

II. Chemical Properties and Tests.

2. **CHEMICAL COMPOSITION.**—The steel shall conform to the following requirements as to chemical composition:

Carbon	0.38—0.52 per cent
Manganese	0.40—0.60 per cent
Phosphorus, not over	0.05 per cent
Sulphur, not over	0.05 per cent

3. **LADLE ANALYSIS.**—An analysis shall be made by the manufacturer from a test ingot taken during the pouring of each melt, to determine the percentage of carbon, manganese, phosphorus, sulphur and silicon. Drillings for analysis shall be taken not less than ¼ in. beneath the surface of the test ingot. A copy of this analysis shall be given the purchaser or his representative. This analysis shall conform to the requirements specified in Section 2.

4. **CHECK ANALYSIS.**—A check analysis shall be made from the finished material representing each melt, by the purchaser or his representative, and shall meet the requirements specified in Section 2.

III. Physical Properties and Tests.

5. **DROP TESTS.**—The axles shall conform to the following drop-test requirements:

(a) The test axle shall be so placed on the supports that the tup will strike it midway between the ends. It shall be turned over after the first and third blows, and when required after the fifth blow. When tested in accordance with following conditions, the axle shall stand the specified number of blows without fracture, and the deflection after the first blow shall not exceed that specified in Table No. 1.

Size of Axle, In.		Capacity of Axle, Lb.	Distance between Supports Ft.	Weight of Tup, Lb.					
				1 640			2 200		
Journal.	Diam. at Center.			Height of Drop, Ft.	Number of Blows.	Max. Deflection, In.	Height of Drop, Ft.	Number of Blows.	Max. Deflection, In.
4¼ by 8	4¾	22 000	3	34	5	7½	....	....	....
5 by 9	5⅜	31 000	3	43	5	6¼	....	....	....
5½ by 10	5⅞	38 000	3	43	7	4½	....	....	....
6 by 11	6$\frac{7}{16}$	50 000	3	....	....	....	40	7	5¼

(b) The deflection is the difference between the distance from a straight-edge to the middle point of the axle, measured before the first blow, and the distance measured in the same manner after the blow. The straight-edge shall rest only on the collars or the ends of the axle.

6. **DROP-TEST MACHINE.**—The anvil of the drop-test machine shall be supported on 12 springs, as shown on the M. C. B. drawings, and shall be free to move in a vertical direction, and shall weigh 17,500 lb. The radii of the striking face of the tup and of the supports shall be 5 in.

7. **NUMBER OF TESTS.**—(a) One drop test shall be made from each melt. Unless otherwise specified, not less than 30 axles shall be offered from any one melt.

(b) If the test axle passes the physical tests, the inspector shall draw a straight line 10 in. long parallel with the axis of the axle, and starting with one end of it he shall prick-punch this line at several points. A piece 6 in. long shall be cut off from this same axle so as to leave some prick-punch marks on each piece of axle. Drillings for chemical analysis shall be taken by using a ⅝-in. drill and drilling in the cut-off end 50 per cent of the distance from the center to the circumference and parallel with the axis of the axle.

IV. Workmanship and Finish.

8. **WORKMANSHIP.**—All axles shall be made and finished in a workmanlike manner and all journals and wheel seats shall be rough-turned. In centering, unless otherwise specified, 60 deg. centers shall be used, with large diameter of counter-sink not less than ⅞ in., and with clearance drilled ½ in. deep.

9. **FINISH.**—The axles shall be free from injurious defects and shall have a workmanlike finish.

V. Permissible Variations and Weights.

10. **PERMISSIBLE VARIATION.**—The axle shall conform in size and shape to the standard M. M. drawings (see Sheet No. 1). Length shall not be less than shown and not more than $\frac{1}{32}$ in. over.

VI. Marking and Storing.

11. **MARKING.**—The manufacturer's name or brand, melt number and month and year when made shall be legibly stamped on each axle on the unfinished portion, unless otherwise specified.

12. **STORING.**—If, as a result of the inspection and tests, more axles are accepted than the order calls for, such accepted axles in excess shall be stamped by the inspector with his own name, and will then be piled and allowed to remain in stock at the works, subject to further orders from the purchasing agent. On receipt of further orders, axles once accepted will not be subjected to further test. In all cases the inspector will keep an accurate record of the melt numbers and the number of axles in each melt which are stored and will transmit this information with each report.

VII. Inspection and Rejection.

13. **INSPECTION.**—(a) The inspector shall examine each axle in each melt for workmanship, defects, and to see whether the axles conform to the dimensions given on the order or tracing, or whether they conform to the specifications. All axles not satisfactory in these respects shall not be considered further. If in this inspection defects are found which the manufacturer can remedy while the inspector is at the works, he may be allowed to correct such defects.

(b) The inspector representing the purchaser shall have free entry at all times, while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the material ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications.

(c) The purchaser may make the tests to govern the acceptance or rejection of material in his own laboratory or elsewhere. Such tests, however, shall be made at the expense of the purchaser.

(d) All tests and inspection shall be so conducted as not to interfere unnecessarily with the operation of the works.

14. **REJECTION.**—Material which, subsequently to above tests at the mills or elsewhere, and its acceptance, develops imperfections shall be rejected and shall be replaced by the manufacturer at his own expense.

15. **REHEARING.**—Samples tested in accordance with this specification, which represent rejected material, shall be preserved 14 days from date of test report. In case of dissatisfaction with results of the tests, the manufacturer may make claim for a rehearing within that time.

APPENDIX B.

Specifications for Boiler and Fire-box Steel for Locomotive Equipment.

1. **SCOPE.**—These specifications cover two grades of boiler steel and shall be designated as flange steel and fire-box steel.

I. Manufacture.

2. **PROCESS.**—The steel shall be made by the open-hearth process.

II. Chemical Properties and Tests.

3. **CHEMICAL COMPOSITION.**—The steel shall conform to the following requirements as to chemical composition:

	Flange.	Fire-box.
Carbon		0.12–0.25 per cent
Manganese	0.30–0.60 per cent	0.30–0.50 per cent
Phosphorus, not over, acid	0.05 per cent	0.04 per cent
Phosphorus, not over, basic	0.04 per cent	0.035 per cent
Sulphur, not over	0.05 per cent	0.04 per cent
Copper, not over		0.05 per cent

4. **LADLE ANALYSIS.**—An analysis shall be made by the manufacturer from a test ingot taken during the pouring of each melt, a copy of which shall be given to the purchaser or his representative. This analysis shall conform to the requirements specified in Section 3.

5. **CHECK ANALYSIS.**—Analysis may be made by the purchaser from a broken tension test specimen representing each plate as rolled, which shall conform to the requirements specified in Section 3.

III. Physical Properties and Tests.

6. (a) The steel shall conform to the following requirements as to tensile properties:

	Flange.	Fire-box.
Tensile strength lb. per sq. in.	55 000–65 000	52 000–62 000
Yield point lb. per sq. in.	0.5 tens. str.	0.5 tens. str.
Elongation in 8 in. min. per cent	$\frac{1\,500\,000}{\text{Tens. str.}}$	$\frac{1\,500\,000}{\text{Tens. str.}}$

(b) The yield point shall be determined by the drop of the beam of the testing machine.

7. **MODIFICATION IN ELONGATION.**—For material over ¾ in. in thickness a deduction of 0.5 from the percentages of elongation specified in Section 6 (a) shall be made for each increase of ⅛ in. thickness above ¾ in. to a minimum of 20 per cent.

8. **BEND TESTS.**—(a) Cold-bend Tests.—The test specimen shall bend cold through 180 deg. without cracking on the outside of the bent portion as follows: For material 1 in. or under in thickness, flat on itself, and for material over 1 in. in thickness, around a pin the diameter of which is equal to the thickness of the specimen.

(b) Quench-bend Tests.—The test specimen, when heated to a light cherry red, as seen in the dark (not less than 1200 °F.), and quenched at once in water, the temperature of which is between 80 and 90 °F., shall bend through 180 deg. without cracking on the outside of the bent portion as follows: For material 1 in. or under in thickness, flat on itself, and for material over 1 in. in thickness, around a pin the diameter of which is equal to the thickness of the specimen.

9. **HOMOGENEITY TESTS.**—A sample taken from a broken tension test specimen shall not show any single seam or cavity more than ¼ in. long, in either of the three fractures obtained in the test for homogeneity, which shall be made as follows: The specimen shall be either nicked with a chisel or grooved on a machine, transversely, about $\frac{1}{16}$ in. deep, in three places about two inches apart. The first groove shall be made 2 in. from the square end; each succeeding groove shall be made on the opposite side from the preceding one. The specimen shall then be firmly held in a vise, with the first groove about one-fourth inch above the jaws and the projecting end broken off with light blows of a hammer, the bending being away from the groove. The specimen shall be broken at the other two grooves in the same manner. The object of this test is to open and render visible to the eye any seams due to failure of weld or to interposed foreign matter, or any cavities due to gas bubbles in the ingot. One side of each fracture shall be examined and the length of the seams and cavities determined, a pocket lens being used if necessary.

10. **TEST SPECIMENS.**—Tension and bend test specimens shall be taken from the finished rolled material. They shall be of the full thickness of material as rolled, and shall be machined to the form and dimensions shown in Figure 1, except that bend test specimens may be machined with both edges parallel.

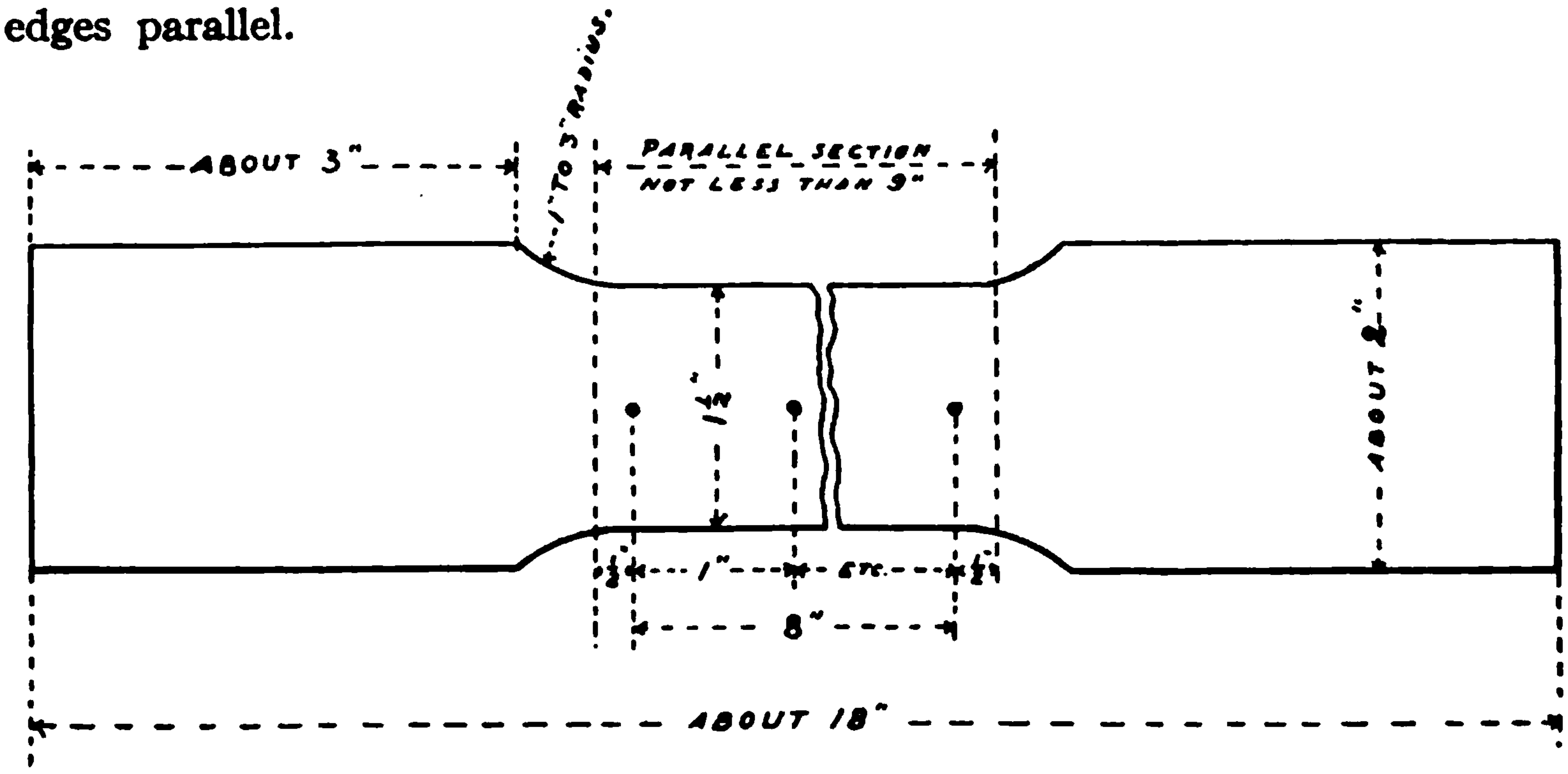


FIG. 1.

11. **NUMBER OF TESTS.**—One tension, one cold-bend and one quench-bend test shall be made from each plate as rolled and in addition one homogeneity test shall be made from each plate made into fire-box material.

(b) If any test specimen shows defective machining or develops flaws, it may be discarded and another specimen substituted.

(c) If the percentage of elongation of any test specimen is less than that specified in Section 7, and any part of the fracture is outside the middle third of the gaged length, as indicated by the scribe scratches marked on the specimen before testing, a retest shall be allowed.

IV. Permissible Variation in Weight and Gage.

12. **GAGE.**—The thickness of each plate shall not vary more than 0.01 in. under that ordered.

13. **WEIGHT.**—An excess over the nominal weight corresponding to the dimensions on the order shall be allowed for each plate, if not more than that shown in the following table, 1 cu. in. rolled steel being assumed to weigh 0.2833 lb.

Thickness Ordered. In.	Nominal Weight Lb. per sq. ft.	Allowable excess (expressed as percentage nominal weight). For width of Plate, as follows:						
		Under 50 in.	50 to 70 in. excl.	70 in. or over.	Under 75 in.	75 to 100 in. excl.	100 to 115 in. excl.	115 in. and over.
1/8 to 5/32	5.10 to 6.37	10	15	20	....	....	....	....
5/32 to 3/16	6.37 to 7.66	8.5	12.5	17	....	....	....	....
3/16 to 1/4	7.65 to 12.20	7	10	15	....	....	....	....
1/4	10.20	....	....	....	10	14	18	....
5/16	12.75	....	....	....	8	12	16	....
3/8	15.30	....	....	....	7	10	13	17
7/16	17.85	....	....	....	6	....	10	13
1/2	20.40	....	....	....	5	7	9	12
9/16	22.95	....	....	....	4.5	6.5	8.5	11
5/8	25.50	....	....	....	4	6	8	10
Over 5/8	....	....	....	....	3.5	5	6.5	9

V. Finish.

14. **FINISH.**—The finished material shall be free from injurious defects and shall have a workmanlike finish.

VI. Marking.

15. **MARKING.**—The name or brand of the manufacturer, melt and slab number and lowest tensile strength for its grade specified in Section 6 (a) shall be legibly stamped on each sheet or piece. The melt and slat shall be legibly stamped on each test specimen.

VII. Inspection and Rejection.

16. **INSPECTION.**—The inspector representing the purchaser shall have free entry at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the material ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. All tests (except check analysis) and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

17. **REJECTION.**—(a) Unless otherwise specified, any rejection based on tests made in accordance with Section 5 shall be reported within five working days from receipt of samples.

(b) Material which shows injurious defects subsequent to its acceptance at the manufacturer's works will be rejected, and the manufacturer shall be notified.

18. **REHEARING.**—Samples tested in accordance with Section 5, which represent rejected material, shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with results of the tests, the manufacturer may make claim for rehearing within that time.

APPENDIX C.

Specifications for Annealed and Unannealed Carbon Steel Axles, Shafts and Other Forgings for Locomotives.

1. **BASIS OF PURCHASE.**—(a) These specifications cover annealed and unannealed carbon steel driving axles, engine and trailer truck axles, main and side rods, piston rods, crank pins and miscellaneous forgings.

(b) The manufacturer may, at his option, furnish annealed forgings when unannealed forgings are specified by the purchaser, provided they conform to the requirements specified for unannealed forgings.

I. Manufacture.

2. **PROCESS.**—The steel may be made by the open-hearth or other process approved by the purchaser.

3. **DISCARD.**—A sufficient discard shall be made from each ingot to secure freedom from injurious piping and undue segregation.

4. **PROLONGATION FOR TEST.**—The manufacturer and the purchaser shall agree upon forgings on which a prolongation for test purposes shall be provided.

5. **HEAT TREATMENT.**—For annealing, the forgings shall be allowed to become cold after forgings. They shall then be uniformly reheated to the proper temperature to refine the grain (a group thus reheated being known as an annealing charge) and allowed to cool uniformly.

II. Chemical Properties and Tests.

6. **CHEMICAL COMPOSITION.**—The steel shall conform to the following requirements as to chemical composition:

Carbon	0.38–0.52 per cent
Manganese	0.40–0.75 per cent
Phosphorus, not over	0.05 per cent
Sulphur, not over	0.05 per cent.

7. **LADLE ANALYSIS.**—An analysis shall be made by the manufacturer from a test ingot taken during the pouring of each melt, a copy of which shall be given to the purchaser or his representative. This analysis shall conform to the requirements specified in Section 6.

8. **CHECK ANALYSIS.**—Analysis may be made by the purchaser from a forging representing each melt, which shall conform to the requirements specified in Section 6. Drillings for analysis may be taken from the forging or from a full-sized prolongation of the same, at any point midway between the center and surface, or turnings may be taken from a test specimen.

III. Physical Properties and Tests.

9. **TENSION TESTS.**—(a) The forgings shall conform to the following minimum requirements as to tensile properties:

For forgings whose maximum outside diameter or overall thickness is not over 12 in. when unannealed and not over 20 in. when annealed.

UNANNEALED.

Size, Outside Diameter or Overall thickness.	Tens. Str. lb. per sq. in.	Yield point lb. per sq. in	Elongation in 2 in. per cent		Reduction of area per cent	
			Inverse Ratio.	Not under.	Inverse Ratio.	Not under.
Not over 8 in..............	75 000	0.5 tens. str.	1 600 000 / tens. str.	18	2 200 000 / tens. str.	24
Over 8 to 12 in., inclusive.....	75 000	0.5 tens. str.	1 500 000 / tens. str.	17	2 000 000 / tens. str.	22

ANNEALED.

Not over 8 in..............	80 000	0.5 tens. str	1 800 000 / tens. str.	20	2 800 000 / tens. str.	32
Over 8 to 12 in., inclusive....	80 000	0.5 tens. str.	1 725 000 / tens. str.	19	2 640 000 / tens. str.	30
Over 12 to 20 in., inclusive...	80 000	0.5 tens. str.	1 650 000 / tens str	18	2 400 000 / tens. str	28

(b) The classification by size of the forging shall be determined by the specified diameter or thickness which governs the size of the prolongation from which the test specimen is taken.

(c) The yield point shall be determined by the drop of the beam of the testing machine.

(d) Tests of forgings shall be made only after final treatment.

10. **TENSION TEST SPECIMENS.**—(a) Tension test specimens shall be taken from a full-sized prolongation of any forging. For forgings with large ends or collars the prolongation may be of the same cross section as that of the forging back of the large end or collar. Specimens may be taken from the forging itself with a hollow drill, if approved by the purchaser.

(b) The axis of the specimen shall be located at any point midway between the center and the surface of the forging, and shall be parallel to the axis of the forging in the direction in which the metal is most drawn out.

(c) Test specimens shall be of the form and dimensions shown in Figure 1.

11. **NUMBER OF TESTS.**—Unless otherwise specified by the purchaser, tests shall be made as follows:

(a) For unannealed forgings one tension test shall be made from each melt.

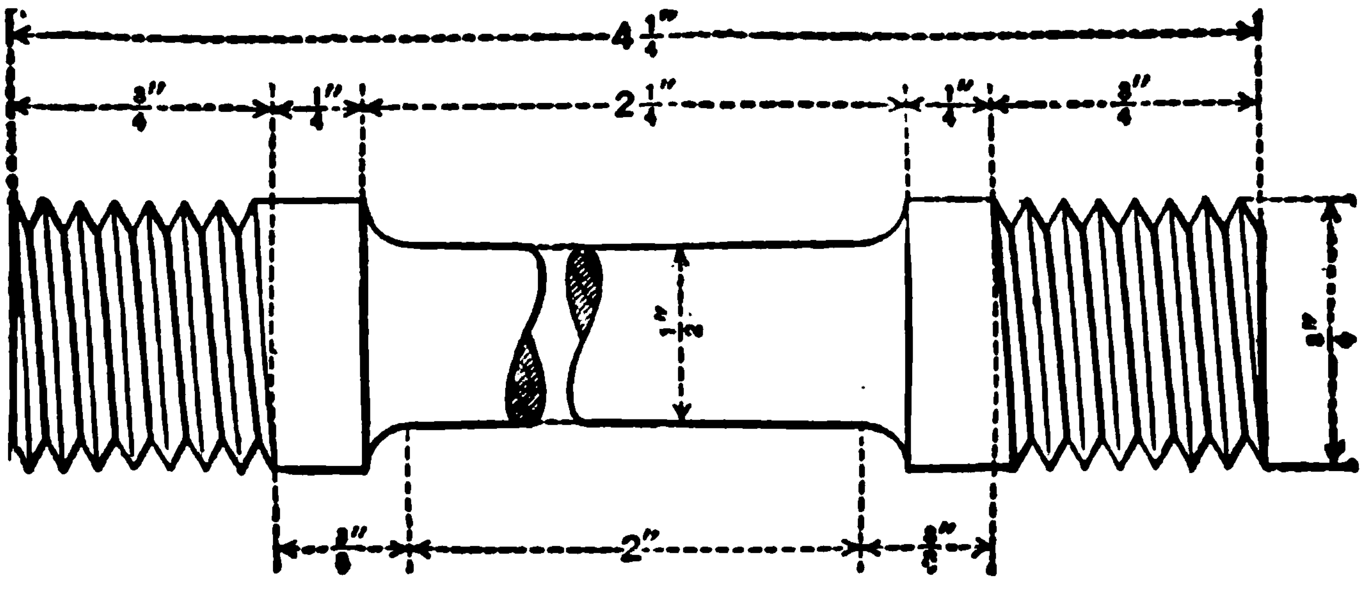


FIG. 1.

(b) For annealed forgings one tension test shall be made from each annealing charge. If more than one melt is represented in an annealing charge, one tension test shall be made from each melt.

(c) If more than one class of forgings by size is represented in any lot, one tension test from a forging of each class by size shall be made as specified in Sections 9 and 10.

(d) If any test specimen shows defective machining or develops flaws, it may be discarded and another substituted.

(e) If the percentage of elongation of any tension test specimen is less than that specified in Section 9 (a), and any part of the fracture is more than ¾ in. from the center of the gage length, as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed.

12. **RETESTS.**—(a) If the results of the physical tests of any test lot do not conform to the requirements specified, the manufacturer may re-anneal such lot, but not more than three additional times unless authorized by the purchaser, and retests shall be made as specified in Section 11.

(b) When annealed forgings are specified, if the fracture of any tension test specimen shows over 15 per cent crystalline, a second test shall be made. If the fracture of the second specimen shows over 15 per cent crystalline, the forgings represented by such specimen shall be reannealed.

IV. Workmanship and Finish.

13. **WORKMANSHIP.**—The forgings shall conform to the size and shapes specified by the purchaser. When centered, 60 deg. centers with clearance drilled for points shall be used.

14. **FINISH.**—The forgings shall be free from injurious defects and shall have a workmanlike finish.

V. Marking.

15. **MARKING.**—Identification marks shall be legibly stamped on each forging and on each test specimen. The purchaser shall indicate the location of such identification marks.

VI. Inspection and Rejection.

16. **INSPECTION.**—(a) The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the forgings ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the forgings are being furnished in accordance with these specifications. Tests and inspection at the place of manufacture shall be made prior to shipment.

(b) The purchaser may make the tests to govern the acceptance or rejection of the forgings at his own laboratory or elsewhere, such tests, however, shall be made at the expense of the purchaser.

(c) Tests and inspection shall be so conducted as not to interfere unnecessarily with the operation of the works.

17. **REJECTION.**—(a) Unless otherwise specified, any rejection based on tests made in accordance with Section 16 (b) shall be reported within five working days from receipt of samples.

(b) Forgings which show injurious defects while being finished by the purchaser will be rejected and the manufacturer shall be notified.

18. **REHEARING.**—Samples tested in accordance with Section 16 (b) which represent rejected forgings, shall be preserved for two weeks from the date of test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.

19. **FREIGHT CHARGES.**—All rejected material will be returned to the manufacturer who shall pay freight charges both ways.

APPENDIX D.

Specifications for Locomotive Cylinder Castings, Cylinder Bushings, Cylinder Heads, Steam Chests, Valve Bushings and Packing Rings.

I. Manufacture.

1. **PROCESS.**—Locomotive cylinders, cylinder bushings, cylinder heads, steam chests, valve bushings and packing rings shall be made from good quality close-grained gray iron cast in a dry mold.

II. Chemical Properties and Tests.

2. **CHEMICAL COMPOSITION.**—Drillings taken from the fractured end of the transverse test bars shall conform to the following limits in chemical composition:

Phosphorus, not over	0.90 per cent
Sulphur, not over	0.12 per cent.
Manganese, not over	0.70 per cent
Silicon for cylinders only, not over	1.60 per cent
Silicon for bushings, heads, chests and rings	1.50 to 1.80 per cent

3. **CHECK ANALYSIS.**—A check analysis of drillings taken from the transverse test bar may be made by the purchaser, and shall conform to the requirements specified in Section 2.

III. Physical Properties and Tests.

4. **TRANSVERSE TESTS.**—When placed horizontally upon supports 12 in. apart and tested under a centrally applied load, the arbitration test bars, specified in Section 6 (a), shall show an average transverse strength of not less than 3200 lb. and an average deflection of not less than 0.09 in. The rate of application of the load shall be from 20 to 40 sec. for a deflection of 0.10 in.

5. **CHILL TEST.**—Before pouring, a sample of the iron shall be taken and chilled in a cast-iron mold, as specified in Section 6 (b). The sample shall be allowed to cool in the mold until it is dark red or almost black, when it may be knocked out and quenched in water. The sample, on being broken, must show a close-grained gray iron, with a well defined border of white iron at the bottom of the fracture. The depth of the white iron must not be less than $\frac{1}{16}$ in. as measured at the center line.

6. **MOLDS FOR TEST SPECIMENS.**—(a) Arbitration Bar.—The mold for the bars is shown in Figure 1. The bottom of the bar is $\frac{1}{16}$ in. smaller in diameter than the top, to allow for draft and for the strain of pouring. The

pattern shall not be rapped before withdrawing. The flask is to be rammed up with green molding sand, a little damper than usual, well mixed and put through a No. 8 sieve, with a mixture of 1 to 12 bituminous facing. The mold shall be rammed evenly and fairly hard, thoroughly dried and not cast until it is cold. The test bar should not be removed from the mold until cold enough to be handled. It shall not be rumbled or otherwise treated, being simply bushed off before testing.

(b) Chill Test.—The form and dimensions of the mold shall be in accordance with Figure 2.

7. **NUMBER OF TESTS.**—(a) Two arbitration test bars, cast as specified in Section 6 (a), shall be poured from each ladle of metal used for one or more cylinders.

(b) One chill test, cast as specified in Section 6 (b), shall be poured from each ladle of metal used for one or more cylinders. The chill specimens may be cast in adjacent molds, but in such cases a space must be provided between the molds. (See Fig. 2.)

IV. Workmanship and Finish.

8. **CHARACTER OF CASTINGS.**—Cylinders shall be smooth, well cleaned, free from shrinkage cracks and from other defects sufficiently extensive to impair the value of the castings, and must finish to blue-print size.

V. Marking.

9. **MARKING.**—Each cylinder shall have cast on it, in raised letters, marks designating the maker, the date of casting, the serial and pattern numbers and other marks specified by the purchaser.

VI. Inspection and Rejection.

10. **INSPECTION.**—(a) The purchaser, or his inspector, shall be given a reasonable opportunity to enable him to witness the pouring of the cylinders and test specimens, as well as to be present when physical tests are made.

(b) In case the inspector is not present to witness the pouring of the castings and test specimens, the manufacturer will make all tests required by the specification, and, upon demand, will furnish the purchaser with a copy of the results of his tests, and will hold the transverse and chill specimens subject to examination by the inspector. The tests made by the manufacturer shall be considered final.

(c) All physical tests and inspection shall be made at the place of manufacture.

11. **REJECTION.**—Unless otherwise specified, any rejection based on tests made in accordance with Section 3 shall be reported within five days from the receipt of samples.

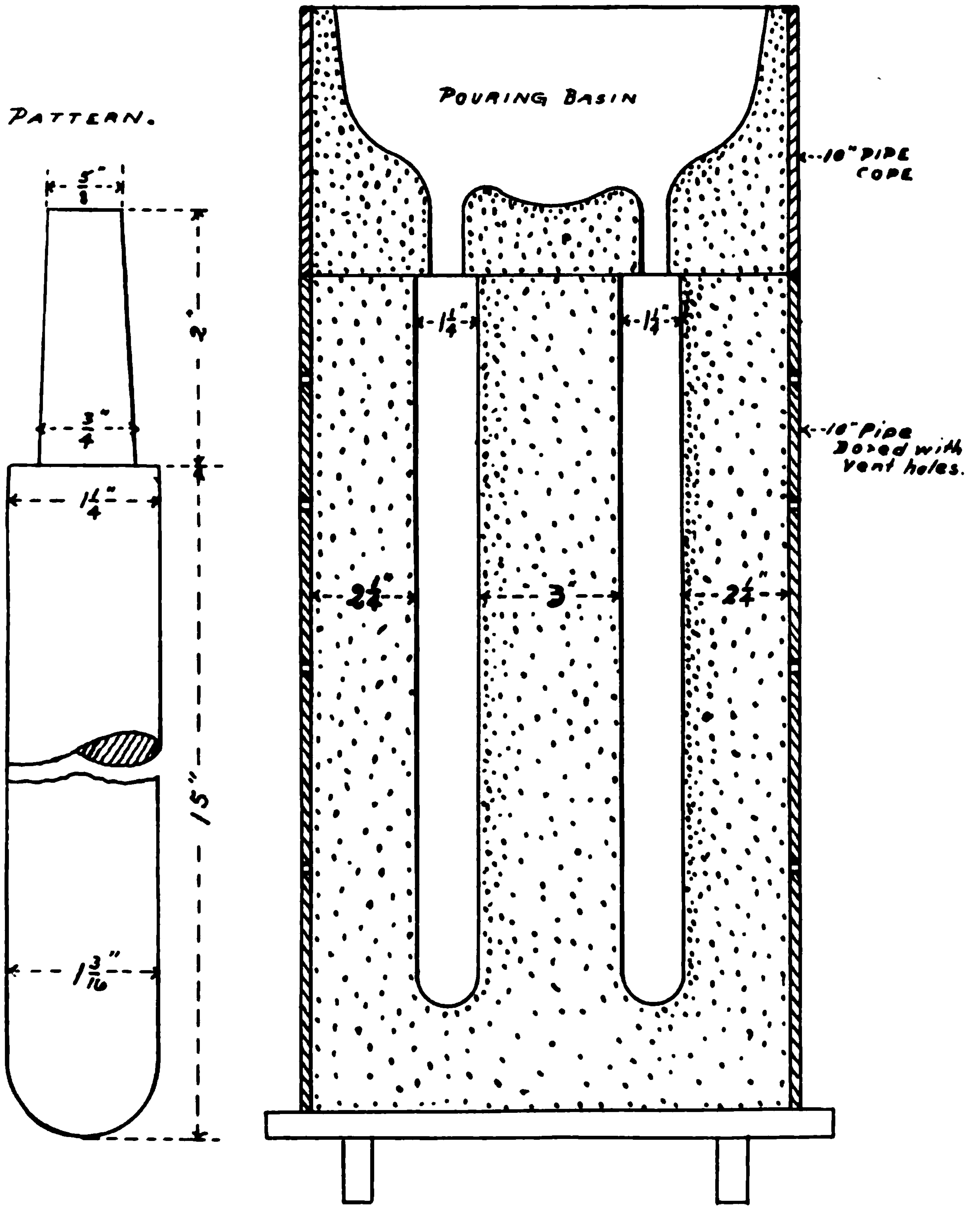


FIG. 1.—MOLD FOR ARBITRATION TEST BAR.

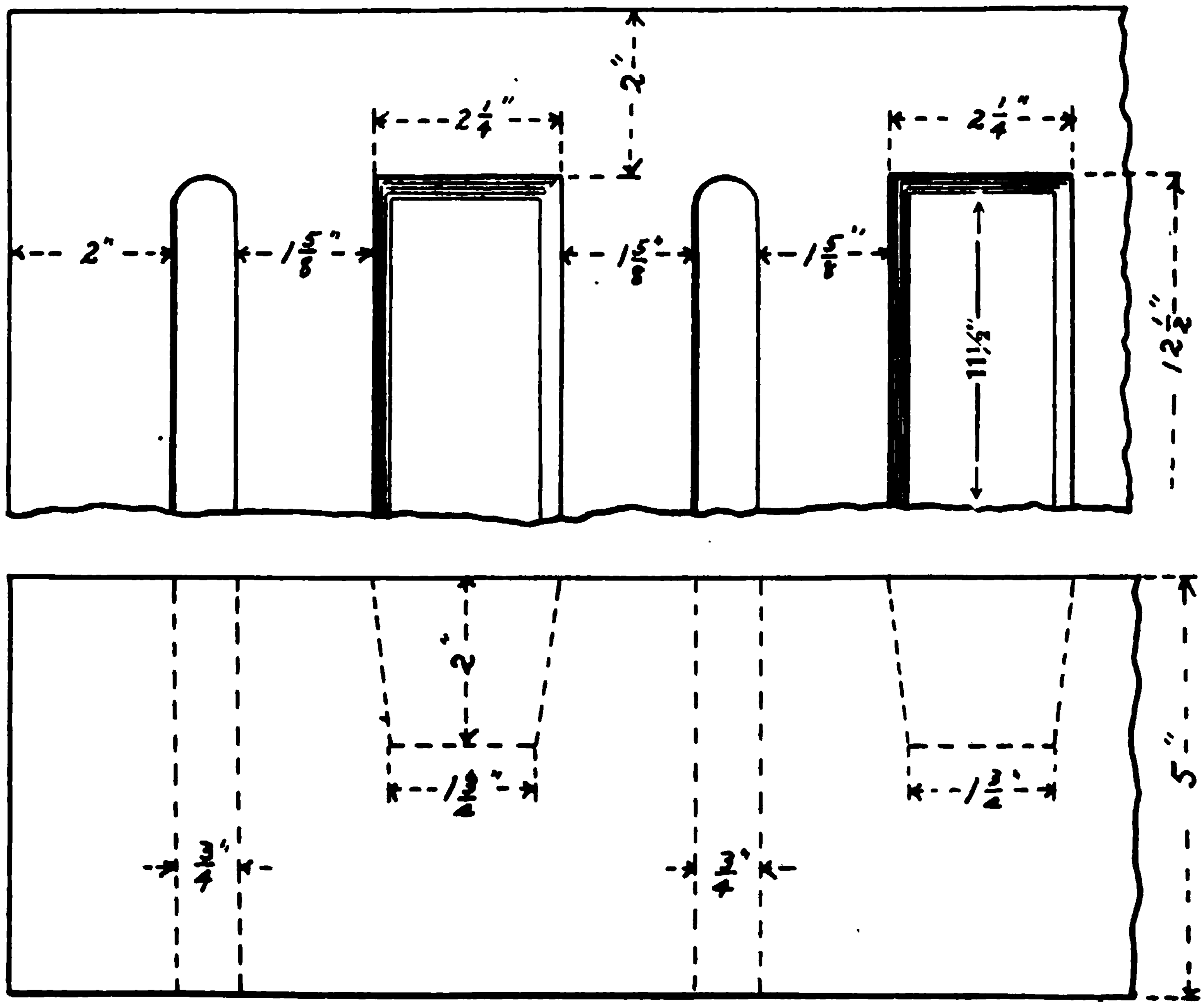


FIG. 2.—MOLD FOR CHILL TEST SPECIMEN.

APPENDIX E.

SPECIFICATIONS FOR STEEL CASTINGS FOR LOCOMOTIVES.

1. **BASIS OF PURCHASE.**—These specifications cover steel castings for locomotive frames, wheel centers and miscellaneous castings.

I. MANUFACTURE.

2. **PROCESS.**—The steel may be made by the open-hearth, crucible or other process approved by the purchaser.

3. **HEAT TREATMENT.**—Castings shall be allowed to become cold. They shall then be uniformly reheated to the proper temperature to refine the grain (a group thus reheated being known as an annealing charge) and allowed to cool uniformly and slowly. If, in the opinion of the purchaser or his representative, a casting is not properly annealed, he may at his option require the castings to be reannealed.

II. CHEMICAL PROPERTIES AND TESTS.

4. **CHEMICAL COMPOSITION.**—The steel shall conform to the following requirements as to chemical composition:

TABLE I.

	Frames.		Wheel Centers and Miscellaneous Castings.
	Grade A.	*Grade B.	
Carbon	0.25—0.37 per cent.	0.37—0.50 per cent.	0.22—0.35 per cent.
Manganese	0.40—0.75 "	0.40—0.75 "	0.40—0.75 "
Phosphorus, not over	0.05 "	0.05 "	0.05 "
Sulphur " "	0.05 "	0.05 "	0.05 "

*When high carbon steel frames are specified this grade shall be used.

5. **LADLE ANALYSIS.**—An analysis shall be made by the manufacturer from a test ingot taken during the pouring of each melt, a copy of which shall be given to the purchaser or his representative. This analysis shall conform to the requirements specified in Section 4.

6. **CHECK ANALYSIS.**—Analysis may be made by the purchaser from a test piece and also from any casting selected at random, and shall conform to the requirements specified in Section 4.

III. Physical Properties and Tests.

7. **TENSION TESTS.**—(a) The steel shall conform to the following minimum requirements as to tensile properties:

	Frames.		Wheel centers and Miscellaneous Castings.
	Grade A.	Grade B.	
Tensile strength lb. per sq. in	65 000	75 000	60 000
Elastic limit " " " "	30 000	35 000	25 000
Elongation in 2 in., min. per cent	20	15	22
Reduction of area, min per cent	28	22	30

(b) The elastic limit shall be determined by an extensometer.

8. **ALTERNATIVE TESTS TO DESTRUCTION.**—In the case of small or unimportant castings, a test to destruction on three castings from a lot may be substituted for the tension tests. This test shall show the material to be ductile, free from injurious defects and suitable for the purpose intended.

9. **TEST SPECIMEN.**—(a) Sufficient test bars shall be furnished from which test specimens required in Section 7 may be selected. They shall be attached to castings weighing 500 lb. or over, when the design of the castings will permit. If the castings weigh less than 500 lb., or are of such a design that test bars can not be attached, two test bars shall be cast to represent each melt; or the quality of the casting shall be determined by testing to destruction as specified in Section 8. All test bars shall be annealed with the castings they represent.

(b) The manufacturer and the purchaser shall agree whether test bars can be attached to castings, on the location of the bars on the castings, on the castings to which bars are attached, and on the method of casting unattached bars.

(c) If the purchaser, or his representative, so desire, a test specimen may be cut from a finished casting, such casting so destroyed shall be paid for by the purchaser.

(d) The purchaser shall have the privilege of taking drillings for analysis from a casting, so long as it does not destroy or weaken the casting.

(e) Tension test specimens shall be of the form and dimension shown in Figure 1. Annealing coupons shall be located at points agreed upon by the manufacturer and the purchaser.

10. **NUMBER OF TESTS.**—One tension test shall be made from each locomotive frame, and in the case of wheel centers and miscellaneous castings, from an annealing charge, or from each melt if more than one melt is in an annealing charge.

Fig. 1.

IV. Variation in Weight.

11. **WEIGHT.**—All castings shall come within the maximum and minimum weight, where shown on the prints, and when castings weighing more than the allowable maximum weight are presented, such castings shall be accepted at the maximum weight provided they meet all other tests, the excess weight being at the expense of the manufacturer.

V. Workmanship and Finish.

12. **WORKMANSHIP.**—The castings shall substantially conform to the sizes and shapes shown on prints, and shall be made in a workmanlike manner. Where surfaces are machined, the castings shall have the proper allowance for finish.

13. **PATTERNS.**—When patterns are furnished by the purchaser, the manufacturer shall make sure that the allowance for shrinkage in these patterns agrees with his own practice. Under no circumstance shall manufacturers change purchasers' patterns without first obtaining permission.

14. **FINISH.**—(a) The castings shall be free from injurious defects. Castings shall not be painted before inspection. Castings rusted to any extent, or covered with any material to hide defects, will be rejected.

(b) Any castings found with blow holes, cracks, low spots or thin sections filled with cement, Smooth-On or like material, shall be rejected and can not be further considered. Oxy-Acetylene, electric or similar welding will not be permitted, unless authorized by the purchaser or his representative, and then only at locations where the defects will not in any way be detrimental to the strength of the casting, this welding only being granted in order to effect a better appearance of the casting.

VI. Marking.

15. **MARKING.**—The manufacturer's name or identification mark and melt number shall be cast on each casting at such location as shall be agreed upon by the manufacturer and the purchaser.

VII. Inspection and Rejection.

16. **INSPECTION.**—(a) The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works, which concern the manufacture of the material ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the castings are being furnished in accordance with these specifications. Tests and inspections at the place of manufacture shall be made prior to shipment.

(b) The purchaser may make the tests to govern the acceptance or rejection at his own laboratory or elsewhere. Such tests, however, shall be made at the expense of the purchaser.

(c) Tests and inspection shall be so conducted as not to interfere unnecessarily with the operation of the works.

17. **REJECTION.**—(a) Unless otherwise specified, any rejection based on tests made in accordance with Section 16 (b) shall be reported within five working days from the receipt of samples.

(b) Castings which show any injurious defects or do not conform to the dimensions given on prints shall be rejected.

(c) Castings which show injurious defects while being furnished by the purchaser will be rejected and the manufacturer shall be notified.

18. **REHEARING.**—Samples tested in accordance with Section 16 (b) which represent rejected material, shall be preserved for two weeks from date of test report. In case of dissatisfaction with results of tests, the manufacturer may make a claim for a rehearing within that time.

ADDENDA.

INSPECTION AND TESTING OF LOCOMOTIVE BOILERS.

FACTOR OF SAFETY.

Section 2. The lowest factor of safety to be used for locomotive boilers constructed after January 1, 1912, shall be 4.

The lowest factor of safety to be used for locomotive boilers which were in service or under construction prior to January 1, 1912, shall be as follows:

Effective January 1, 1915, the lowest factor shall be 3, except that upon application, this period may be extended not to exceed one year, if an investigation shows that conditions warrant it.

Effective January 1, 1916, the lowest factor shall be 3.25.

Effective January 1, 1917, the lowest factor shall be 3.5.

Effective January 1, 1919, the lowest factor shall be 3.75.

Effective January 1, 1921, the lowest factor shall be 4.

Item 3. Maximum Allowable Stress on Stays and Braces.—For locomotives constructed after January 1, 1915, the maximum allowable stress per sq. in. of net cross sectional area on fire box and combustion chamber stays shall be 7500 lb. The maximum allowable stress per sq. in. of net cross sectional area on round, rectangular or gusset braces shall be 9000 lb.

For locomotives constructed prior to January 1, 1915, the maximum allowable stress on stays and braces shall meet the requirements of Rule No. 2, except that when a new fire box and wrapper sheet are applied to such locomotives, they shall be made to meet the requirements of Rule No. 3.

STAY BOLT TESTING.

Item 24. METHOD OF TESTING FLEXIBLE STAY BOLTS WITHOUT CAPS.— Flexible stay bolts which do not have caps shall be tested once each month, the same as rigid bolts.

Each time a hydrostatic test is applied, such stay bolt test shall be made while the boiler is under hydrostatic pressure not less than the allowed working pressure, and proper notation of such test made on Form No. 3.

NOTE.— To provide a proper service period between hydrostatic tests, removal of caps from flexible stay bolts and removal of flues for locomotives which are stored for an extended period, the time for performing such work on locomotives which are stored in good condition for one or more full calendar months may be extended without filing application, as follows:

Hydrostatic tests will be due after 12 months' service, provided such service is performed within 24 consecutive months.

Removal of caps from flexible stay bolts will be due after 18 months' service, provided such service is performed within 30 consecutive months.

Removal of flues will be due after three years' service, provided such service is performed within four consecutive years.

Time out of service must be properly covered by out-of-service reports and notation showing the months out of service on account of which the extension is claimed made on the back of inspection reports and cab cards.

No extension of time as provided above will be allowed for portions of a month.

If the locomotive is out of service when any of the above work is due, it need not be performed until just prior to the time the locomotive is returned to service.

STEAM GAGES.

Item 29. SIPHON.— Every gage shall have a siphon of ample capacity to prevent steam entering the gage. The pipe connection shall enter the boiler direct, and shall be maintained steam-tight between boiler and gage.

The siphon pipe and its connections to the boiler must be cleaned each time the gage is tested.

SAFETY VALVES.

Item 35. SETTING OF SAFETY VALVES.— Safety valves shall be set to pop at pressures not exceeding 6 lb. above the working steam pressure. When setting safety valves, two steam gages shall be used, one of which must be so located that it will be in full view of the person engaged in setting such valves; and if the pressure indicated by the gages varies more than 3 lb. they shall be removed from the boiler, tested and corrected before the safety valves are set. Gages shall in all cases be tested immediately before the safety valves are set or any change made in the setting. When setting safety valves the water level in the boiler shall not be above the highest gage cock.

FILING REPORTS.

Item 52. A copy of the monthly inspection report, Form No. 1, or annual inspection report, Form No. 3, properly filled out, shall be placed under glass in a conspicuous place in the cab of the locomotive, before the boiler inspected is put into service.

Item 54. SPECIFICATION CARD.— A specification card, size 8 by 10½ in., Form No. 4, containing the results of the calculations made in determining the working pressure and other necessary data, shall be filed in the office of the chief inspector of locomotive boilers, for each locomotive boiler. A copy shall be filed in the office of the chief mechanical officer having charge of the locomotive. Every specification card shall be verified by the oath of the engineer making the calculations, and shall be approved by the chief mechanical officer. These specification cards shall be filed as promptly as thorough examination and accurate calculations will permit. Where accurate drawings of boilers are available, the data for specification card, Form No. 4, may be taken from the drawings, and such specification cards must be completed and forwarded prior to July 1, 1912. Where accurate drawings are not available, the required data must be obtained at the first opportunity when general repairs are made, or when flues are removed. Specification cards must be forwarded within one month after examination has been made, and all examinations must be completed and specification cards filed prior to July 1, 1913, flues being removed if necessary to enable the examination to be made before this date.

When any repairs or changes are made which affect the data shown on

the specification card, a corrected card or an alteration report on an approved form, size 8 by 10½ in., properly certified to, giving details of such changes, shall be filed within 30 days from the date of their completion. This report should cover:

(a) Application of new barrel sheets or domes.

(b) Application of patches to barrels or domes of boilers, or to portion of wrapper sheet of crowbar which is not supported by stay bolts.

(c) Longitudinal seam reinforcements.

(d) Changes in size or number of braces, giving maximum stress.

(e) Initial application of superheaters, arch or water bar tubes, giving number and dimensions of tubes.

(f) Changes in number or capacity of safety valves.

Report of patches should be accompanied by a drawing or blue-print of the patch, showing its location in regard to the center line of boiler, giving all necessary dimensions and showing the nature and location of the defect. Patches previously applied should be reported the first time boiler is stripped to permit an examination.

MR. DUNHAM: In addition to the recommendation on page 4, it has been suggested to the committee, and the committee in turn refers the matter to the Association, that there be included as a postscript to the recommendation of the committee, the contents of Circular No. 121 as issued by the Division of Locomotive Boiler Inspection covering what might be termed the automatic extension of the time of removal of caps from flexible staybolts, removal of flues, and hydrostatic tests. I think you are all familiar with that, and there is no necessity for reading it over here.

THE PRESIDENT: You have heard this report, and unless there is some objection we will accept it and lay the report open for discussion. If there is no discussion on the subject, I suggest a motion be made that the committee be continued and the recommendations of the committee be referred to the letter ballot.

MR. C. D. YOUNG (Penn. R. R.): Before that motion is put I would discuss the silicon content in the chemical composition for cast iron, appendix D. The committee in rendering the report

incorporates the original silicon requirement for bushings, heads, chests and rings. With the increasing use of superheated steam, it is becoming very desirable to have a close-grained hard iron for this purpose, and I believe the time has arrived when we should reduce the silicon requirement to make it agree with the cylinder mixture requirement. If we make the silicon the same for the smaller parts, such as the bushings, heads, chests and rings, the fact that they are smaller parts and have the same silicon content, will make them sufficiently hard to give them more wear, especially in superheater locomotives, and with the consent of the Chairman I make a motion that the bushings, heads, chests and rings have the same silicon requirement as that which is specified for cylinders, namely, 1.60 per cent.

THE PRESIDENT: Do you accept that amendment, Mr. Dunham?

MR. DUNHAM: I do, I think it is entirely proper.

The motion to accept the report of the committee as amended, was put to vote and carried.

THE PRESIDENT: At the end of the report there are several suggestions regarding certain matters to be submitted to letter ballot, and for the Secretary to handle, and I think a motion would be in order to carry out the recommendations of the committee.

MR. YOUNG (Penna. R. R.): I make such a motion, Mr. President, that the Secretary be requested to make alterations or corrections to 2, 3, 4 and 6, referring to these paragraphs in the report, and that paragraphs 1, 5, 7, 8, 9, 10, 11 and 12 be referred to letter ballot for changes in standards or recommended practice.

The motion was put to vote and carried.

MR. DUNHAM: I will say for the information of the members that I have here some sample stops for the air-brake handles which have been developed by the Westinghouse Company, and also some sample stops, which anybody can make. These are to show that there will be no confusion, or any high cost involved, in following out the recommendations of the committee. I will leave these here for inspection.

THE PRESIDENT: The next subject on the program for this session is the report of the Committee on Safety Appliances. I am entered as the chairman of that committee, but the report will be made by Mr. M. K. Barnum, of the B. & O. R. R.

REPORT OF COMMITTEE ON SAFETY APPLIANCES.

MR. M. K. BARNUM (B. & O. R. R.): Mr. President and Gentlemen: We have only a verbal report to make. The Committee on Safety Appliances met with the special Committee on Relation of Railway Operation to Legislation and the subject was discussed at some length, but it was not thought necessary to make any written report, in view of the fact that the time limit expired several years ago for the full equipment of locomotives with safety appliances required by the Federal law. The committee would therefore respectfully recommend that it be discharged.

THE PRESIDENT: You have heard the report. If there is no objection it will be accepted. I think it would be a good thing to have a motion along the line suggested, that the committee be discharged.

MR. DUNHAM: I move that the report of the committee be accepted and the committee be discharged.

Motion seconded and carried.

THE PRESIDENT: The next business on the program is a Topical Discussion entitled "Advantages, if any, of Compounding Superheater Locomotives." This discussion will be opened by Mr. Lawford H. Fry, of the Baldwin Locomotive Works.

TOPICAL DISCUSSION: ADVANTAGES, IF ANY, OF COMPOUNDING SUPERHEATER LOCOMOTIVES.

MR. LAWFORD H. FRY (Baldwin Loco. Works): Mr. President and Gentlemen: The conclusions which I wish to offer for discussion this morning are, first, that compound cylinders applied to a single expansion locomotive will show a saving in fuel and

water of from 15 or 25 per cent, whether saturated or superheated steam be used; and second, that since in securing the saving some additional complication is introduced, the question as to whether compounding is practically worth while or not can only be answered after studying the local conditions in each case.

Having commenced by presenting my conclusions, let me now show the considerations on which they are based. Take first the process by which compounding effects a saving in steam consumption. If any given range of expansion be divided between two cylinders instead of being carried out in one, the same amount of work can be obtained with a smaller consumption of steam. This is due to the fact that the range in temperature in the steam coming in contact with any one portion of the cylinder will be reduced, and consequently the thermal losses due to initial condensation will be less. In addition to this, compounding offers a further opportunity for economy, by making it feasible to use a higher ratio of expansion than can be efficiently employed with a single-expansion engine.

In a single-expansion locomotive it will be found that the greatest economy is obtained with a cut-off at about 30 per cent of the stroke, and that with a shorter cut-off, in spite of the theoretical advantage of a higher expansion, the practical result will be a decrease in efficiency. Take, for example, the K-29 superheater, Pacific type locomotive of the Pennsylvania Railroad, tests of which are described in the Company's Bulletin No. 19. The diagram on page 98 of this bulletin shows that while the rate per indicated horse-power-hour was 18 lb. for cut-offs between 30 per cent and 35 per cent, it grows to 20 lb. when the cut-off is shortened to 25 per cent. This is typical of locomotives generally and is largely due to the action of the valve gear, which, if it is to be adapted to all the requirements of locomotive service, can not operate economically at very short cut-offs. To quote from the bulletin referred to above: "The ideal conditions in regard to the expansion of steam in the cylinder would be to admit steam up to the cut-off point and then expand it to the atmospheric pressure before release. With the necessity for draft on the fire and the practical limitations of valve gears this is not possible, and the steam must be discharged at a comparatively

high pressure." The bulletin then gives figures showing that the number of expansions (that is, the volume of steam at release divided by the volume at cut-off) is 1.37 for a cut-off of 45 per cent, 1.75 for a cut-off at 30 per cent, and 2.0 for a cut-off at 25 per cent. This means that at the most economical cut-off of 30 per cent, the steam is being released at a pressure of about 51 lb. per square inch. As this steam may carry some superheat, or at least is perfectly dry, there would obviously be considerable advantage in expanding it further, and thus converting to useful work the heat in the steam which is otherwise wasted in the exhaust. The use of compound cylinders will enable the effective ratio of expansion to be practically doubled.

It should be noted that it is not only the limitations of the valve motion which prevent a high ratio of expansion in a single cylinder on a locomotive. If the valves were modified so as to make efficient the use of a high expansion in a single cylinder, there would still be a mechanical advantage in dividing the expansion into two cylinders so as to produce a more uniform cylinder tractive force. With a high ratio of expansion in a single cylinder there will be a wide difference between the initial and the final pressures and consequently a considerable difference between the tractive force during admission and the mean tractive force average throughout the stroke. Therefore, if the cylinders be made large enough to allow the mean tractive force to utilize a proper proportion of the weight on drivers, there will be a danger of slipping during the time of maximum cylinder pressure while steam is being admitted. By dividing the expansion, the difference between maximum and minimum pressure in each cylinder is reduced, and with the cylinders quartered a more uniform tractive force is obtained. Practically all of the foregoing applies equally whether the locomotive uses saturated or superheated steam, but the last point is of special importance in connection with superheated steam, since with this medium there is more to be gained by a high ratio of expansion. In fact, if the expansion is insufficient the steam, when exhausted, will still be superheated, a condition which represents avoidable waste. Having stated briefly the reasons for expecting economy in steam consumption with compound cylinders, let us now see what results

are being obtained in practice. In this country, with the exception of some balanced compounds on the A. T. & S. F. Ry., little has been done with compound cylinders on superheaters except in the case of Mallet engines, and here there is no chance for a direct comparison with similar engines working single expansion. In Europe, however, there is a growing tendency to use compound cylinders with superheated steam, and all reports show that the results are satisfactory.

In France the first superheater engines were single expansion, but now five of the six principal railways have adopted four-cylinder compound superheater engines as standards for both freight and passenger service, and after comparative trials are abandoning the single expansion cylinders. A paper by Mr. Sauvage before the English Institution of Mechanical Engineers reports that the Paris-Lyons & Mediterranean Railway in tests of Pacific type engines in service found that the single expansion consumed from 19 to 21.5 lb. of water per one horse-power per hour, and the compound from 13.5 to 15.0 lb., a saving of nearly 30 per cent.

In Germany, the introduction of superheating did away with compounding almost completely for several years, but in the past three years compound cylinders have been reintroduced for the latest high-speed passenger engines of the 4-6-0 type, and are reported as giving satisfactory results. Comparative tests have shown a water consumption per horse-power hour of 23.8 lb. for the single expansion and 18 lb. for the compound, approximately 25 per cent saving.

In England the majority of superheater engines have single expansion cylinders, but some of the railroads are trying compounding. Mr. Fowler, of the Midland Railway, in a paper read before the Institution of Civil Engineers, last year, gave some results of comparative tests between four engines, all similar except for the quality of steam used and the number of cylinders. Two of the engines were two-cylinder single expansion, one using saturated and one superheated steam, while the other two were three-cylinder compounds, one using saturated, the other superheated steam. Taking the performance of single-expansion saturated steam locomotive as a basis of comparison,

the following savings in coal were observed: Compounding alone, 15 per cent; superheating alone, 25 per cent; compounding and superheating, 37.5 per cent.

From these figures you will see that it appears that the compound cylinders, when applied with saturated steam, saved about 15 per cent, and when applied with superheated steam, about 17 per cent of coal. This confirms what I have often heard from French railway engineers, that the saving to be effected by compounding is practically the same percentage, whether applied with saturated or with superheated steam.

Having seen the evidence that the saving can be obtained, let us consider the difficulties to be overcome in order to secure it. In the first place there will be a slight increase in first cost, and an increase in weight of two or three per cent, the latter being offset, however, by the better balance to be obtained with three or four cylinders. There will be more pistons, rods, valves, etc., requiring increased attention and maintenance, but the division of power between more than two cylinders may prove advantageous by reducing the power to be transmitted by each rod.

In addition to this multiplication of parts the designer must provide for a crank axle, and must find space for the large low-pressure cylinders. These problems have been solved in European practice; and although the difficulty is increased by the size of the locomotives in this country, its solution should not be beyond the power of our American designers.

There is one further point of importance to be considered if a compound is to run at anything more than a slow speed, and that is the question of back pressure. The larger area of the low-pressure cylinder makes the engine more susceptible to the evil effects of back pressure. In order that the engine may work successfully and efficiently at high speed the blast pipe must operate with the lowest possible pressure and the exhaust passage be designed to offer the least possible resistance to the steam.

With this statement I will return to the conclusions with which I started, that compound cylinders will give a saving in coal and water with either saturated or superheated steam. With expensive fuel and ample opportunities for supervision and maintenance, the conditions will favor compounding; but whether the

saving is practically worth while or not will depend on local conditions.

Mr. G. R. Henderson (Baldwin Loco. Works): I agree that the facts as stated by Mr. Fry are interesting, and I was wondering whether he had complete data regarding the French and German tests, in which the compounding showed so much gain with superheated steam. As Mr. Fry stated, and we all know, the principal gain in compounding is by eliminating cylinder condensation, and that has been very well proven in cylinders of the uni-flow type, in which the steam passes in at one end and out at the center, thereby maintaining a comparatively uniform temperature in the cylinder, and in this design simple cylinders show practically the same steam economy as compound engines of the same size.

We also know that the superheater gets its main value in reducing or doing away with the cylinder condensation, and if we do away with the condensation by one means, we can not expect to do away with it a second time, but must gain principally by increasing the volume of the steam. For that reason I would like to know whether the details of this test are sufficiently complete to make the case clear. For instance, it would be very easy to make a compound locomotive more economical by the use of superheater steam, more so than to make a superheater locomotive more economical by compounding. What I mean is that a certain temperature up to 200 or 250 degrees of superheat will prevent any condensation in the simple cylinder up to probably one-fifth cut-off, or five expansions nominally. If we go ahead and increase our superheat still greater, we increase the volume of our steam, and it just happens that we get about the same ratio of increased work. For instance, if with superheat at about 100 degrees we reduce our cylinder condensation probably one-half, and if with superheat at 200 degrees we reduce our cylinder condensation probably about 33 per cent, if we proceed beyond that point, even if we should have superheated steam at the moment of exhaust, we have so enlarged our volume per pound of steam or water that we can go on with the increasing amount of superheat and get a corresponding amount of economy. These things look to the fact that it is necessary in these tests to know

whether in all cases the amount of superheat, that is, the temperature of the steam, was the same, and whether all the conditions were strictly comparable. If Mr. Fry has the data, I ask him to put them in the records at his convenience, so that it can accompany this discussion. I would like to know if that is the case.

MR. FRY: I have very complete data on the English tests here, and so far as I can see they were as nearly comparable as possible, I have not equally complete data on the French tests nor on the German tests, but I simply give them as indicating the general trend of practice in those countries. The railroads give these figures, and at the same time on their superheater locomotives they are changing from single-expansion to compound locomotives.

Mr. Henderson suggested that the opportunity for saving by compounding was less with superheated than with saturated steam, because the initial condensation is done away with. The answer is that the superheater makes a saving at the other end of the stroke. With the single-expansion engine compounding cuts down the initial condensation, while with a superheater engine it tends to save the steam which would be thrown away dry or slightly superheated. With the single-expansion superheater, you do not get much initial condensation, but you have to throw away good dry steam at a fairly high pressure, while if you put a low-pressure cylinder on behind the first you can make that steam still do some work.

MR. YOUNG: I think the conclusions Mr. Fry has drawn are quite correct, except that I would like to add that there hardly seems the possibility in this country, with our operating conditions, that we will go to compounding to any great extent on high-speed engines. High-speed carries with it a fairly high maintenance of the parts, which, as you all know, is rather difficult to obtain. Whether compounding or superheating would give you as fast an engine, with equivalent draw-bar pull, as the simple superheater engine, I much question. Even though you may have superheated steam with the compounding, you still have the problem of getting rid of a large quantity of steam from the low-pressure cylinder, and also of obtaining a sufficient

amount of steam to supply the high-pressure cylinder, in comparison with the amount you must furnish to the low-pressure cylinder. It seems to me, for American practice, it is a question whether we will use compounding, for passenger work particularly. The requirements of slow speed lend themselves to compounding, and it is the ideal thing to have.

I am rather surprised that Mr. Fry did not make the case a bit stronger for a higher superheat with simple engines than what we have to-day. I believe if we could provide a valve design that would withstand a temperature of 800° F., and you could obtain superheat in that vicinity, you would then get a proportional increase that would warrant a higher superheat than we are getting to-day with the average modern locomotive. I believe if that matter is to be met, so far as economy is concerned, it will have to be met in that direction. The question of material and parts is the thing which plays the most important rôle at this time in developing such a locomotive.

We are getting experience every year in the maintenance of parts subject to high superheat, and our experience in that direction should lead to the development of an efficient valve, different from the piston type of valve, perhaps a poppet type, made of material which will withstand high superheat.

Whether we could obtain the superheat desired from the boiler without affecting its evaporative capacity is also a question of superheater design. I believe firmly that we will hardly be warranted in this country in going to compounding for our superheater engines.

The point raised by Mr. Henderson I believe is brought out by Mr. Fowler's test in England. He points out the case of a compound engine equipped with a Schmidt superheater, where on comparative runs, the economy of water was from 22 lb. to 26 lb., the water getting down as low as 18 lb. That is what you get ordinarily with a fairly high superheater and a simple engine. If that is the case, it would hardly seem to me that we would be warranted in going to compounding unless we confine it almost entirely to slow speed engines.

Prof. L. E. Endsley (University of Pittsburgh): I think Mr. Young's point regarding the increasing of the superheat is

important. We must, however, take care of the lubrication and some other things, and if we can do that, the gain of the last 100 degrees is going to be more than the gain of the first 100 degrees of superheat. That has been shown clearly in many tests which I have conducted, from 80 degrees of superheat to 240 degrees of superheat, making three steps — 80, 160 and 240. The last 80 degrees is worth three times as much as the first 80 degrees. If I could go to 320 degrees, the last 80 degrees would probably be worth as much as the third 80 degrees.

I do not think we will get much advantage through compounding our American locomotives, if we get a large enough cylinder in the simple engine. All we want to do is to reduce pressure in our steam down to the point where it will produce enough draft to steam the locomotive, and if you put on a compound cylinder and reduce it too low, to make the engine steam, you will not get the increased power we are getting to-day, by reason of the superheat.

Some of the roads found it was necessary to reduce the size of the nozzle in superheater locomotives, while it was known that the steam going out was superheated and going out in larger volume than it would be going out in the case of a saturated locomotive. I mean that probably 25 per cent of the steam in the saturated locomotive is going out as water, not increasing the steaming of the locomotive in any degree, and in reducing the steam consumption of the superheater we are putting it out at so much higher temperature, that we have a greater volume by reason of this temperature.

We are superheating to-day to such an extent that we are exhausting superheated steam, and the gain from increased volume is a fine thing, and is probably worth more at the last end than at the first end in the reduction of condensation.

I think it is important that we get something to carry a higher degree of superheat, and then we will not have to go to the compounding and add to our troubles by the employment of a double set of cylinders and other things. Engines will show a higher efficiency compounded with superheated steam, there is no question about that, but we must maintain the compound locomotive in a high degree of efficiency in order to get the increased efficiency.

Mr. Young: Mr. Endsley's statement that the value of the 80 degrees of superheat will be three times that of the first 80 degrees, is no doubt based on data of Purdue University, published in the A. R. M. M. A. 1911 Proceedings and apparently substantiated by Fig. 13 therein, showing the degrees of superheat plotted in comparison with the coal per i. h. p. hour.

Our Bulletin No. 24 of the Pennsylvania Railroad covering tests in which the speed and cutoff conditions are kept constant and no change made except that of superheat, does not justify a curve such as that shown in Fig. 13 referred to, the trend of this Purdue curve being the reverse of that of the Pennsylvania Railroad curves.

Paragraph 31, page 91, and conclusions 8 and 12, pages 94 and 95 of part 2 of Bulletin No. 24, cover the point in question. In further explanation, Purdue curve No. 13 assumes, as shown in Purdue Fig. 3, that the superheat was in direct proportion with the evaporative performance of the boiler, and therefore that for 200 lb. pressure it can be derived by applying the Purdue equation $T = 90 + 16.5\,H$ where H is the equivalent evaporation per square foot of heating surface per hour and T the superheat in degrees Fahrenheit. Tests on the Pennsylvania Railroad Testing Plant do not show that the superheat is directly proportional to the evaporation, but that as the evaporation increases there is a tendency for the superheat to fall off. This is shown on Fig. 9 of Bulletin No. 24. In Fig. 1 I have plotted a new diagram showing the coal per i. h. p. hour for different degrees of superheat at each of several cutoffs at a speed of 240 revolutions per minute, and also, on the same sheet from Marks & Davis tables, the weight of one cubic foot of steam at the various superheats. It will be seen that the dotted lines for the different cutoffs have the same trend as the change in weight of steam. There is also shown the data of the Purdue tests, the solid lines drawn through the different cutoff points therein being mine. It is seen here that the curvature of the lines for constant cutoff and speed by the Pennsylvania Railroad tests is the reverse of the Purdue curve, Fig. 13, the actual points of which as plotted and as stated above, hardly seem to justify such a curve. Based upon this

curve, from Fig. 13, however, the Purdue statement, made just prior to the conclusions, is that the first 80 degrees of superheat reduced the coal consumption 2.8 per cent, the second 80 degrees 10.0 per cent, and the third 80 degrees 16.6 per cent, which statement, if Fig. 13 is correct, is entirely justified, but which, in view of subsequent tests, I believe is in error and should have the trend shown by the dotted curves for the various cutoffs. These dotted curves indicate that the first 80 degrees give an economy of 18.0 per cent, the second 80 degrees 14.0 per cent, and the third 80 degrees 12.0 per cent. I therefore question whether it is not misleading to make the statement that the superheat in the last 80 degrees, as suggested by Mr. Endsley, is worth three times that in the first 80 degrees, but I again wish to emphasize that in my opinion it is desirable to go still further in the superheat, if it is possible with a proper efficiency of the superheater, and maintain the valve and piston packing material against excessive wear.

MR. W. H. FLYNN (M. C. R. R.): We have ninety-nine compound engines on the Michigan Central, and at the present time twelve of them are equipped with superheaters. The results have so pleased the Operating Department, as well as the Mechanical Department, that I think I am safe in saying we will apply superheaters to the balance of these locomotives.

On the division where we conducted one of our tests, we found we could increase the tonnage loading of the superheater compound 15 per cent above the tonnage that a saturated compound could satisfactorily handle. That seems an astonishing figure, but it is true; and the superheater compound would handle this increased tonnage more satisfactorily than a saturated compound, and at the same time burn less coal.

I think this is a very strong argument in favor of the superheater compound locomotive, and I think that the results obtained on the New York Central, which road has applied superheaters to compound locomotives, have been equally as favorable.

MR. PRATT: Were they in passenger or freight service?

MR. FLYNN: Slow speed freight service. We had occasion to put one of these superheater compounds on a passenger train,

and we found the engine would run about ten or twelve miles faster than an engine of the same class without the superheater.

MR. PRATT: I will ask Mr. Flynn if he had a lot of superheater engines, whether he would proceed to compound them; and similarly, if he had a lot of saturated engines, if he would proceed to superheat them?

MR. FLYNN: The engines we have, which are simple Mikado type equipped with superheaters, would require an entirely new arrangement of cylinder, because I do not believe we could get a sufficiently large low-pressure cylinder on either side and keep within the clearance limits.

MR. HENDERSON: There is a difference between superheating compounds and compounding superheaters. With Mallet locomotives, for instance, there is a great advantage in the compounding feature, one being that the flexible pipes carry steam of moderate pressure, about 100 lb. The superheater is a great advantage there, because there is certainly some loss in temperature in passing through the receiver pipe, and you can put a superheater on that engine, to make up for cylinder condensation and also loss of temperature in your pipe, and there is no question, in such an engine it is a great advantage to have low pressure in the flexible pipes. I feel that if we need a little more economy, we had better get a little more superheat. The problem of superheating compounds is more logical than that of compounding superheaters.

THE PRESIDENT: Does Mr. Fry wish to say anything in closing this discussion?

MR. FRY: I do not want to go on record as advocating compounding without restriction. I was asked to bring out the advantages, if any, of compounding superheater locomotives, and what I have tried to do is to show that economy is being attained in Europe, but that before it is introduced over here we must weigh very carefully the disadvantages of the increased complication, and as a general proposition I doubt very much if it will be widely adopted in this country.

THE PRESIDENT: The next business will be the report of the

Committee on Smoke Prevention, Mr. E. W. Pratt, A. S. M. P., C. & N. W. Ry., is chairman.

Mr Pratt presented the report, as follows:

REPORT OF COMMITTEE ON SMOKE PREVENTION.

To the Members:

Your committee has conducted no new tests of smoke-preventing apparatus on steam locomotives, but has received inquiries from several members relative to the improved methods and results concerning this problem in the city of Chicago; hence we present herewith a brief description thereof in the belief that the development of similar arrangements in other cities may be productive of equally good practical results.

Another year's use of the steam-air jets, quick-action blowers, etc., as recommended in our report to the 1913 convention, has further confirmed the belief that locomotives equipped therewith may be kept comparatively free from smoke, provided the engine crews are instructed in the proper use of these devices and carry out such instructions at all times.

The Department of Smoke Inspection of the City of Chicago has accepted these devices as standards and recommends them to those inquiring. This department consists of the city smoke inspector, two assistants (all mechanical engineers), ten mechanical engineers and ten deputy observers, covering not only the railroads, but the entire city. The expense to the city is about $39,000 per year.

The railroads in Chicago have a total of 54 smoke inspectors, representing an annual expenditure of about $65,000. Previous to 1913 the inspectors employed by each railroad observed only the locomotives of their respective road and it was found that some of the most flagrant violations occurred on locomotives in foreign territory. Hence it was that the Railroad Smoke Inspectors' Bureau, under the direction of a subcommittee of the General Managers' Association, was formed. This bureau is composed of the chief smoke inspectors of all railroads in the city and holds its meetings biweekly, inviting thereto all railroad men interested in smoke prevention. The smaller roads not having a chief smoke inspector are represented by a master mechanic or road foreman of engines. The following are the subcommittee's instructions:

"Joint Smoke Inspection Bureau of the Railroads Operating in Chicago.

INSTRUCTIONS FOR MAKING REPORTS.

"It should be borne in mind that the primary object of this bureau is to increase the effectiveness of the smoke inspectors now employed by the various railroads in the city of Chicago.

"The committee appointed to draw up forms for making reports and

instructions governing the same has held several meetings, and attach sample copies of two forms adopted for this purpose.

"Form 'A' will be a duplicate postal card; one part of which will have U. S. government stamp and will be addressed to the Joint Smoke Inspection Bureau.

"Each inspector should carry a book in which to record all dense smoke observed, giving in each case the information called for on the postal card 'A,' and before the end of each day he should copy on the postal card the reports which are to go to the Joint Smoke Inspection Bureau and on the duplicate card the same information which is to be sent through railroad mails to the officer of each road interested, who will be designated to receive these reports. Estimates of smoke density should be based on the Ringelmann chart, and each inspector should be furnished with a small chart for this purpose.

"Form 'B' will be a biweekly summary of the reports received by the joint bureau, which will be compiled by the bureau and sent out to all of the roads.

"Inspectors should be thoroughly impressed with the idea that from now on they are joint inspectors and must report impartially *all cases* of dense smoke emitted, whether by locomotives owned by the railroad on whose pay-rolls they are carried or by those belonging to some other road.

"To obtain the best results, it is absolutely necessary that these reports be copied and mailed on the same date the observations are made."

Forms "A" and "B" are shown in Figs. 1 and 2, respectively.

JOINT SMOKE INSPECTION BUREAU

of Railroads Operating in Chicago.

Date..............................191.....

Inspector..

of......................................R. R. noted following cases of dense smoke emission on above date:

ROAD	Eng. No.	TIME		Density No.	LOCATION	REMARKS
		From	To			

FIG. 1.—FORM "A"

RAILROAD SMOKE INSPECTORS' ASSOCIATION OF CHICAGO.

Summary of Reports for the Two Weeks Ending November 19, 1914.

	Number of Reports Filed	*Number of Loco-motives Operated in Chicago	Per Cent of Loco-motives Reported	Average Density of Cases Reported	Number of Report made by Inspectors of each R.R.
A. T. & S. F. Ry.	....	‡45	....	....	....
B. & O. R. R.	....	‡28	....	....	....
B. & O. C. T. R. R.	....	‡36	....	....	....
Belt Ry. of Chicago	1	45	.16	100	....
C. & O. Ry. of Ind.	....	‡ 6	....	....	....
C. & A. R. R.	....	‡38	....	....	....
C. & E. I. R. R.	....	‡34	....	....	1
C. & N. W. Ry.	....	‡302	....	....	....
C. & W. I. R. R.	....	‡27	....	....	....
C. B. & Q. R. R.	....	‡93	....	....	3
C. G. W. R. R.	1	11	.65	80	....
C. I. & S. R. R.	....	‡ 5	....	....	....
C. I. & L. Ry.	....	‡16	....	....	....
Chicago Jct. Ry.	....	‡45	....	....	....
C. M. & St. P. Ry.	....	‡166	....	....	....
C. Riv. & Ind. Ry.	....	‡ 8	....	....	....
C. R. I. & P. Ry.	....	‡80	....	....	1
C. U. T. Ry.	....	‡12	....	....	....
E. J. & E. Ry.	....	‡47	....	....	....
Erie R. R.	1	23	.31	80	....
Gr. Trunk Ry.	....	‡46	....	....	1
Ill. Cent. R. R.	1	138	.03	80	....
Ill. Nor. Ry.	....	‡11	....	....	....
I. H. Belt R. R.	1	3	2.38	100	....
L. S. & M. S. Ry.	....	‡80	....	....	....
Manf. Jct. Ry.	1	4	1.79	100	....
Mich. Cent. R. R.	....	‡30	....	....	....
M. St. P. & S. S. M. Ry.	....	‡16	....	....	....
N. Y. C. & St. L. R. R.	....	‡32	....	....	....
Pere Marq. R. R.	1	17	.42	80	....
Penna. Lines	1	146	.05	80	2
Pullman Co.	....	‡ 6	....	....	....
Wabash R. R.	....	‡49	....	....	....

File ‡720. December 10, 1914. (*) Based on Engine Days. (‡) None reported.

FIG. 2.

These reports are for the private use of the railroads and are not furnished the city. However, the work of the railroad bureau is heartily approved by the city authorities and has been productive of greater coöperation between the various railroads, so much so that the smoke reading made by the city the year following its inception was over 50 per cent lower.

It should be understood that the city smoke department construes one minute of No. 3, 4 or 5 smoke as a violation of the law.

Up to September, 1914, the city's railroad reports were made from semiannual readings covering about 10,000 observations made in a period of 40 consecutive days by two deputy inspectors, whose entire duties for this time were confined to locomotives, and who selected, as places for observation junction points, large yards, etc., where a large number of engines were operated. As these inspectors remained an entire day or more at such points, their presence was soon discovered by the engine crews, who, by special efforts, were thus enabled to make an unusually good showing. Also former reports only covered full minute readings.

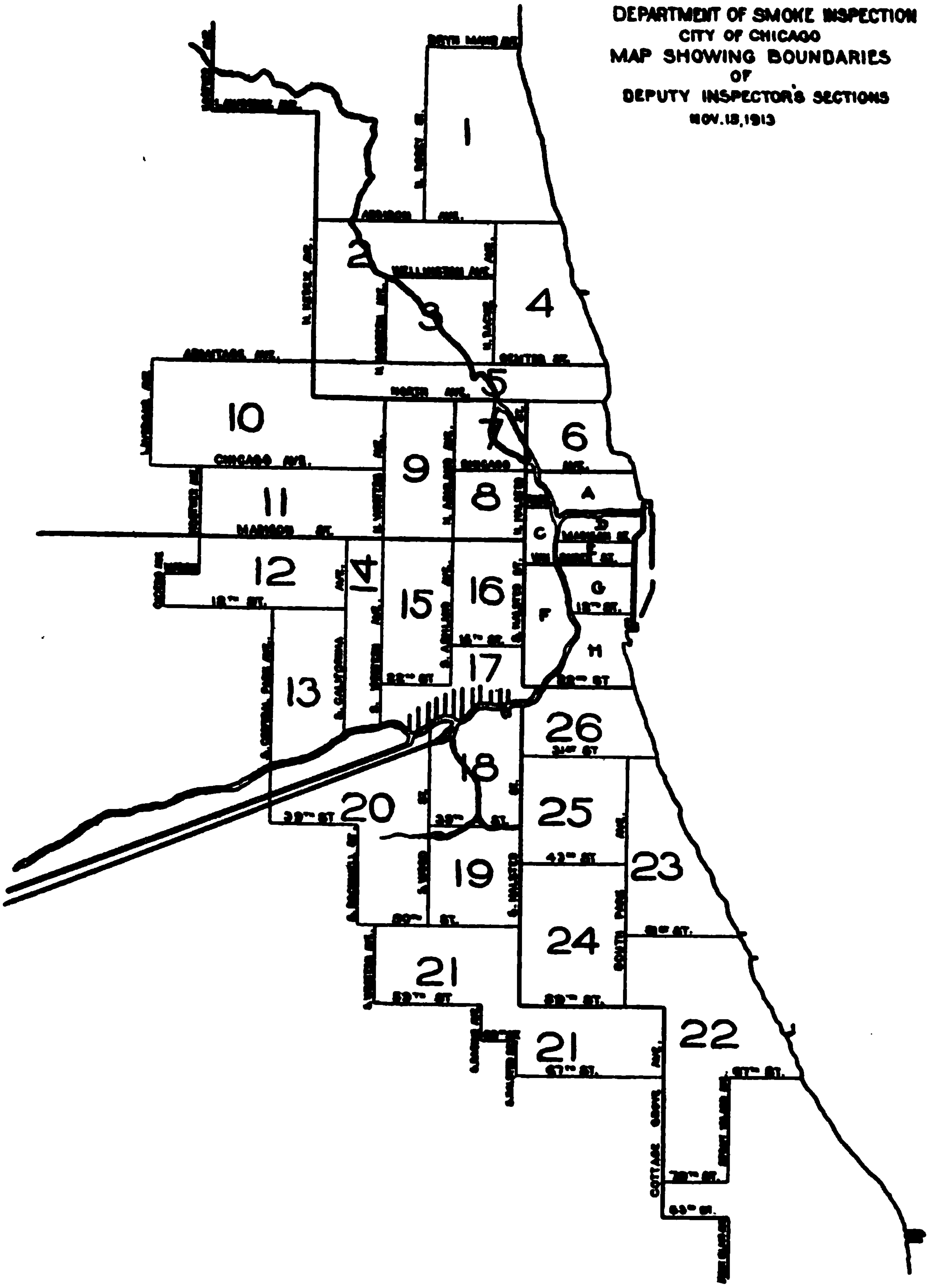
Commencing September, 1914, all city inspectors were instructed to each read locomotive smoke for a total of two hours each day. This to be done in one period or in several periods of 15 min. or more. These inspectors, being assigned to various districts in the city (as shown in Fig. 3), make it certain that the railroad observations will not be confined to any one locality, and they are, therefore, more indicative of normal conditions. From these observations the city issues a monthly report, as shown in Fig. 4, and the semiannual report as shown in Fig. 5 is made up from the six monthly statements. All readings are made in accordance with the Ringelmann method of determining smoke density, and the *engine-minute* is the unit employed.

An *engine-minute* covers the observation of one locomotive during the entire minute. During this minute, 14 seconds or less is not counted; 15 to 45 seconds is counted as one-half minute; 45 to 75 seconds is reported as a full engine-minute.

The density of smoke is obtained by its comparison with the Ringelmann chart, as published by the U. S. Bureau of Mines, a miniature reproduction of which is shown therewith (Fig. 6). One minute of No. 1 density is a *smoke unit,* and the calculations are as follows: One-half minute of No. 3 density is 1.5; one-half minute of No. 1 density is 0.5; five minutes of No. 0 density is 0, etc.

The percentage of smoke density shown in Figs. 4 and 5 is obtained by multiplying the smoke units by 20 (each Ringelmann unit being 20 per cent) and dividing the product by the total engine-minutes.

In order that the city inspectors shall read the smoke density correctly, applicants for these positions pass through a probationary period, during which time, under the direction of an experienced inspector, they make thousands of smoke readings with a full-sized Ringelmann chart set up 50 ft. from them in the direction of the stack under observation. These


DEPARTMENT OF SMOKE INSPECTION
CITY OF CHICAGO
MAP SHOWING BOUNDARIES
OF
DEPUTY INSPECTOR'S SECTIONS
NOV. 18, 1913
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ADDISON AVE.
WELLINGTON AVE.
ARMITAGE AVE.
NORTH AVE.
CHICAGO AVE.
MADISON ST.
12TH ST.
22ND ST.
31ST ST.
39TH ST.
43RD ST.
51ST ST.
55TH ST.
59TH ST.
67TH ST.
79TH ST.
COTTAGE GROVE AVE.

FIG. 3

CHICAGO SMOKE DEPARTMENT.

TABULATION RAILROAD RINGELMANN OBSERVATIONS.

Month of February, 1915.

NAME OF RAILROAD	Number of Observations	Engine-Minutes	Smoke Units	Per Cent Density
A. T. & S. F.	34	39.5	6	3.04
B. & O.	14	23	7	6.09
B. & O. C. T.	21	23.5	11	9.36
Belt Ry.	16	21.5	6.75	6.28
C. B. & Q.	126	126.5	31	4.9
C. G. W.	20	25.5	3.75	2.98
C. I. & L.	15	12.5	6.5	10.4
C. I. & S.	2	3	1.5	10
C. J.	45	43.5	26	12.41
C. M. & St. P.	221	248.5	107.25	8.63
C. R. I. & P.	122	121	42.	13.86
C. R. & I.	13	16	20.5	25.62
C. S. L.	....	....	....	....
C. & A.	45	65	12	3.69
C. & E. I.	18	14	2.75	3.93
C. & N. W.	450	493	155.75	6.32
C. & O.	1	.5	.25	10
C. & W. I.	51	46.5	15.25	6.56
E. J. & E.	....	....	....	....
Erie	24	19	8.5	8.95
Grand Trunk	17	21	2	1.91
Ill. Cent.	243	223	51.75	4.64
Ind. H. B.	4	7.5	2	5.33
Ill. Nor.	13	17.5	9.5	10.86
Lake Shore	105	110	16.25	2.95
Mfrs. Junc.	....	....	....	....
Mich. Cent.	23	25	7.75	6.2
N. Y. C. & St. L.	25	26	7.25	5.58
Pennsylvania	106	117.5	38.25	6.51
Pere Marquette	3	2.5	....	....
Pullman	....	....	....	....
Soo Line	11	11.5	6	10.44
Wabash	27	25.5	36	28.23
TOTAL	1 815	1 929	6 41.5	6.65
TOTALS FOR				
September	4 262	4 911.5	2 900.75	11.81
October	4 340	5 757.5	2 439.5	8.47
November	1 876	2 521	1 044	8.6
December	3 368	3 782.5	2 007.75	10.62
January, 1915	3 068	3 674.5	1 709.25	9.63
February	1 815	1 929	641.5	6.65
	18 729	22 576	10 742.75	9.52

FIG. 4.

DEPARTMENT OF SMOKE INSPECTION
CITY OF CHICAGO

RAILROAD SMOKE DENSITIES FROM
September, 1914, to February, 1915, both inclusive.
IN ORDER OF THEIR STANDING

	RAILROAD	Number of Observations	Engine-Minutes	Smoke Units	Per Cent Density
1	C. & N. W.	4 064	5 233.5	1 613.75	6.17
2	N. Y. Cent.	720	691.5	218	6.35
3	A. T. & S. F.	302	373.5	125.25	6.77
4	C. G. W.	321	435.5	149.5	6.86
5	C. B. & Q.	1 563	1 599	598.5	7.49
6	I. C.	2 199	2 256.5	953	8.44
7	N. Y. C. & St. L.	192	222.5	94	8.46
8	C. M. & St. P.	2 054	2 550.5	1 123	8.77
9	Pennsylvania	1 327	1 815.5	800.25	8.82
10	Soo Line	174	201	90.25	8.98
11	M. C.	249	295	135	9.15
12	Grand Trunk	387	545	263.5	9.67
13	C. & E. I.	257	286.5	139.25	9.72
14	B. & O. C. T.	379	617.5	309.75	10.03
15	C. I. & L.	175	187	94.75	10.14
16	B. & O.	197	306	175.5	11.47
17	C. R. I. & P.	1 077	1 091.5	637	11.67
18	I. H. B.	29	43.5	26	11.95
19	Ill. Northern.	71	87.5	55.5	12.69
20	C. & A.	586	641	419	13.07
21	C. & W. I.	521	642.5	422.5	13.15
22	Pere Marquette	114	121	82.25	13.59
23	Erie	220	257	186.5	14.57
24	Wabash	403	555.5	406.5	14.64
25	C. & O.	34	31	23	14.84
26	Belt	178	232	195.5	16.85
27	C. I. & S.	29	28	29.5	21.07
28	C. J.	810	1 097.5	1 219.25	22.22
29	C. R. & I.	97	132	157	23.79
	TOTAL	18 729	22 576	10 742.75	9.52

FIG. 5.

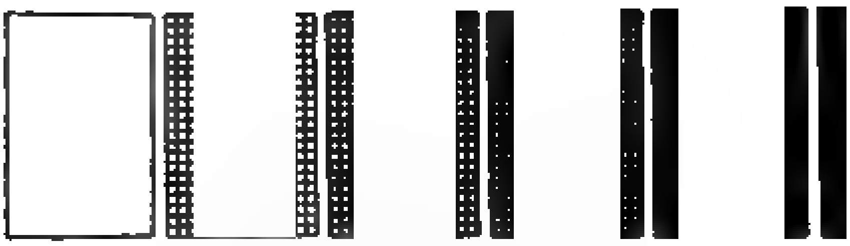


FIG. 8.—THE RINGELMANN SCALE FOR GRADING THE DENSITY OF SMOKE PREPARED BY THE HAMLER-EDDY SMOKE RECORDER CO., CHICAGO.

men are under Civil Service, and their standing is based largely upon their ability to correctly read smoke density.

The members of the Railroad Smoke Inspectors' Association and the city inspectors frequently have joint classes in the reading of smoke density, in order that uniformity may be obtained in the case of independent individual observations.

One of the encouraging features of this plan of coöperation is that it has so fully met with the approval of the city smoke department that the latter has voluntarily opened all its record books, pertaining to railroads, to members of the railroad bureau, and most remarkable has been the reduction in the percentage of density of railroad smoke during the past few years, shown as follows:

	Per Cent.
1910	22.3
1912	10.74
1913	6.06
*1914	7.41

* The figure for 1914 was made up from the summer reading of 1914 (by old method), and the reading for September, October and November, 1914, by the new method. This figure would be lower but for the change in method.

In closing, mention should be made of the fact that the Chicago city smoke department from its inception not only sought but has received the coöperation of the railroads.

Although the largest railroad center in the world, it is probable that Chicago is second to no other American city in the effort that has been expended toward the elimination of smoke nor in the results obtained. It is said that, "comparing Chicago, plant by plant and stack by stack, with other American cities using soft coal, Chicago is by far the cleanest of all."

E. W. PRATT, Chairman,
J. F. DEVOY,
W. C. HAYES,
T. R. COOK,
JOS. CHIDLEY,
J. J. SULLIVAN,
W. J. TOLLERTON,
Committee.

THE PRESIDENT: Gentlemen, you have heard the report. Unless there is some objection it will be thrown open for discussion. Is there anything being done in other cities along these lines? Mr. Redding, have you anything to say about the smoke conditions in Pittsburgh?

MR. D. J. REDDING (P. & L. E. R. R.): We have quite an organization for the prevention of smoke in Pittsburgh. You who only ride through the town may not realize it, but there has been great progress made in the abatement of smoke, not only from locomotives, but from other causes. There was a meeting held in regard to smoke abatement some time ago at which some of the smoke inspectors were present. It happened to be a foggy night, and some people commented on the fact it was a nice night to hold a meeting on a subject of that kind, as it was so foggy you could not see a man sixty feet away. The Chief Smoke Inspector said to these people that he thought it was a good occasion to call their attention to the fact that the efforts for smoke abatement in Pittsburgh had succeeded in taking the smoky taste out of the fog.

There is one question I would ask Mr. Pratt, and that is, whether the committee is able to make any recommendations as to the best method of caring for smoke from locomotives being fired up in roundhouses located in the city limits.

MR. PRATT: I do not think there is anything new with regard to the prevention of smoke in roundhouses. There are a few plants in operation now where the smoke is washed. We spent — I was going to say wasted, but I do not think that is hardly true— on the Chicago & North Western Ry. in experimenting with that problem, many thousands of dollars, and the money which we expended, although it did not bring the return we hoped for to our road, was no doubt of advantage to other roads who have experimented along similar lines. We are waiting now for some one to denaturize the smoke electrically, and I think perhaps some of the Pennsylvania Railroad men can tell us whether they have accomplished that.

THE PRESIDENT: Is there any one here from the Lake Shore R. R. who can tell of their experiences in this direction?

MR. M. D. FRANEY (N. Y. C. R. R.): Speaking for the Fourth District of the New York Central Railroad Company, we have a

smoke-washing device in our engine house at Englewood station, Chicago. This is located at Indiana avenue and Sixty-third street, and is adjacent to the White City, a popular amusement park.

We handle approximately eighty locomotives at the above point every twenty-four hours. We found in our early experiments that the various acids from the smoke and water were very destructive to metals, and as a result the conduits were made of a material called transite and the water tubs were made of concrete. We found that it was necessary to use wood fastened together with wooden pegs, the entire surface to be thoroughly coated with tar so as to resist the action of the acid.

The device consists of three large concrete basins, a large wooden stack, a 78-in. steel fan, motor driven. A 60-in. circular conduit, made of transite material, extends around that portion of the house usually occupied by smoke jacks. This conduit is just below the roof of the house. Extending down from the under side of the conduit to each pit is a telescopic iron jack having a funnel on the lower end that may be pulled down on top of the locomotive stack. This smoke jack is free longitudinally and laterally, to a limited extent, so as to conform to the position of the locomotive. Each jack is provided with a damper that is closed when that particular jack is not required.

At the center of the thirty-four-stall house the 60-in. conduit branches out, making a connection with the 78-in. fan referred to above. Three wooden ducts branch out from the 78-in. fan, each leading to one of the water compartments referred to above. Directly above the outlet of each one of these three branches is a hood similar to a bell with a closed top. The fan draws the gases from the locomotive through the telescopic jacks, through the conduit and forces them into the three outlets leading to the water tanks which outlets are partly filled with water. There is also a steam jet in each one of the outlets which helps to heat and to agitate the water. The gases are forced into the bell referred to above, pass down through the water and, by means of a series of baffles, are thoroughly washed and sprayed with water, the gases disappearing through the stack with steam whiteness, the solids and carbons appearing on the top of the water in the large vats in the form of a foam. This is skimmed off and dried, having the

appearance of pure lamp black. We obtain from eight to ten barrels of this material per day of twenty-four hours.

The plant is working very satisfactorily and thoroughly washes the smoke, but as stated above the acids are very injurious to the metals and to the concrete.

This enginehouse was built without any smoke jacks, Mr. MacBain having promised that he would provide a smoke-washing device that would obviate the necessity of smoke jacks. We expected to find the device quite expensive. As the members well know, in order to prevent black smoke and to comply with the city ordinance of Chicago, it is necessary to use the blowers continuously. This requires fuel and water.

After starting the smoke washer we found, except when building up a fire, that the action of the fan was sufficient to maintain the fire in the locomotive without the use of the blower. In this way we save considerable coal and water. I am not prepared at this time to give official figures, but from some tests we have made, the saving is very satisfactory.

All of our locomotives are equipped with brick arches, arch tubes and the steam jet form of smoke consumer. Each locomotive is equipped with two blowers, one on the right and one on the left side, each blower 1¼ in. diameter. The blower on the left, or fireman's side, is connected to the steam jet smoke consumer. Our crews are instructed on the elimination of smoke and how to prevent same when firing a locomotive. Where there is a violation and our investigation shows that the smoke-preventing mechanism on the locomotive is in proper condition and the locomotive is in proper working order, we discipline the offenders. Where it is found to be a defect on the locomotive same is remedied at once and the party responsible for such defect is disciplined in proportion to the offense.

Mr. L. R. Pomeroy: Is there any salvage from the by-products of these plants?

Mr. Franey: We have disposed of considerable of the carbon, but I am not prepared to say to just what extent it has been made a paying proposition.

The President: Are there any further remarks? Are Pitts-

burgh and Chicago the only cities where they have trouble from smoke?

MR. WM. ELMER (Penna. R. R.): I can say a word about Buffalo. The city council has endeavored for a year or more to agree on some ordinance which would be acceptable to the manufacturing industries and to the railroads, regarding smoke prevention. Without an ordinance the railroads have done a good deal toward reducing the amount of smoke which the engines are making. A portion of the best residence district is in the vicinity of one of the steam lines, so that a great deal of complaint comes from those residents, but in that district, the railroad which operates there is making extraordinary efforts to keep down the smoke and trying to please the citizens.

Whatever has been done in Buffalo has been done voluntarily and all the railroads are alive to the situation and making every possible effort to prevent the making of very dense smoke, so as to forestall any drastic efforts on the part of the council.

THE PRESIDENT: Are there any further remarks to make on this subject? If not, I will call on Mr. Pratt to close.

MR. PRATT: I do not think there is anything special to say except to urge on those who have not had to go through the experience we have gone through, to cut down the smoke nuisance as much as they can before the authorities take action. If we had done that in Chicago we would not now be up against the expensive problem of electrification. The final report on that matter has not yet been made public, but it will cost approximately $192,000,000 for electrification, and another $100,000,000 for incidental betterments due to changes otherwise necessary. We will have to do some business to provide the interest on that $300,000,000.

THE PRESIDENT: Before we adjourn I want to compliment our Secretary on the very excellent arrangements of this room. I do not think we have ever had a room where the acoustic properties were so satisfactory, the seating so well arranged, and everything so comfortable. I know he has given a great deal of his time to looking after it.

The meeting will now adjourn.

THURSDAY'S SESSION.

The President, Mr. F. F. Gaines, called the meeting to order at 9:50 o'clock.

THE PRESIDENT: The time has arrived to open the meeting. The Secretary has some reports to make.

THE SECRETARY: I have the following report:

CHICAGO, June 7, 1915.

To the Members of the American Railway Master Mechanics' Association, Chicago:

We hereby certify that we have verified the footings of the cash book kept by the Secretary of the American Railway Master Mechanics' Association, vouched the disbursements for the year, and reconciled the bank balance as of June 5, 1915, all of which we found correct and in good order. Our audit, however, as to receipts, did not extend beyond verifying the footings of the receipts shown in the cash book.

BARROW, WADE, GUTHRIE & CO.,
Certified Public Accountants.

We also have the report of the Auditing Committee, as follows:

REPORT OF AUDITING COMMITTEE.

To the Members:

We hereby certify that we have audited the accounts and compared the books of the Treasurer, and find the same to be correct and in accordance with the report submitted. Respectfully submitted,

W. E. DUNHAM,
M. D. FRANEY,
M. H. HAIG,
Committee.

THE PRESIDENT: You have heard these reports of the Certified Public Accountants and the Auditing Committee. A motion to accept and approve these reports is in order.

MR. C. A. SELEY: I move that the reports be received and approved.

Motion seconded and carried.

THE PRESIDENT: The first order of business is the report on Locomotive Headlights. Mr. Crawford is not here. The Secretary has a letter from him which he will read.

The Secretary read the following letter and enclosure from Mr. D. F. Crawford:

PENNSYLVANIA LINES WEST OF PITTSBURGH.
PITTSBURGH, PA., May 29, 1915.

Mr. J. W. Taylor, Secretary, Master Mechanics' Association,
1112 Karpen Building, Chicago, Ill.:

DEAR SIR,— Please note copy of letter I have to-day written Mr. J. T. Wallis, General Superintendent Motive Power, Pennsylvania Lines East of Pittsburgh, in regard to the attendance of Mr. J. L. Minick at the convention of the Association in June. As neither Mr. Cook nor myself will be able to attend the convention, and Mr. Minick is thoroughly familiar with the report of the Headlight Committee, I would like very much to have the privilege of the floor extended to him, so if it is found necessary he can take part in the discussion of this report. Won't you kindly bear this in mind and make such arrangements as may be necessary to give Mr. Minick an opportunity to take part in the discussion of the report if found desirable. Yours truly,

D. F. CRAWFORD,
General Superintendent Motive Power.

PENNSYLVANIA LINES WEST OF PITTSBURGH.
PITTSBURGH, PA., May 29, 1915.

Mr. J. T. Wallis, General Superintendent Motive Power:

DEAR SIR,— Referring to our conversation in Chicago, it will be impossible for me to attend the Master Mechanics' convention at Atlantic City in June, and I would like very much to have Mr. Minick attend this convention and take part in the discussion of the report of the Headlight Committee. I have written Secretary Taylor and requested him to make such arrangements as may be necessary to give Mr. Minick the privilege of the floor, as I understand he is not a member of the Association. I shall appreciate it very much indeed if you can see your way clear to have Mr. Minick attend the convention. Yours truly,

General Superintendent Motive Power.

THE PRESIDENT: Mr. Barnum, will you present the report?

MR. BARNUM: Mr. President, Mr. Minick has done much of the active work in gathering the data, and I think he can

probably present the report more clearly than any of the members of the committee. I therefore suggest that he be allowed to do so.

THE PRESIDENT: Mr. Minick, will you please step forward?

MR. J. L. MINICK (Penna. R. R.): Mr. President, this report, though rather brief, covers about fifteen pages, and I will not read all of it as my voice is not in very good condition.

The report was presented by Mr. Minick, as follows:

REPORT OF COMMITTEE ON LOCOMOTIVE HEADLIGHTS.

To the Members:

The sense of the 1914 Convention was that the Headlight Committee should be continued in order that questions raised in connection with headlights could be referred to the proper parties for attention, and that the committee should recommend for adoption by the Association such standards, etc., as could be fixed from the data collected in the Columbus tests and as the present state of the art would permit. They were also instructed to recommend an accepted method of photometering headlights.

There has been so much legislation regarding locomotive headlights, and it has varied so widely in detail, in the various parts of the country, that your committee does not believe that there has been any great attempt made by the various railroads to produce a headlight to meet the Master Mechanics' requirements.

There are, however, a number of oil-lighted headlights on the market which will meet these requirements, and at least one which will give the maximum apparent beam candle-power recommended by the committee. There has also been developed during the last year at least three arrangements of reflectors with incandescent lamps which will meet these requirements.

In connection with the incandescent lamp headlight, your committee feels that the following standards should be adopted in order to direct the development of this type of headlight.

VOLTAGE.

The voltage of the system should be fixed at 6 volts, for the following reasons:

1. This voltage will permit the use of standard 6-volt automobile lamps in the cab, markers, etc. Lamps in the 25-34 volt class, of the proper candle-power for this service, are not now made, and they will be difficult to develop.

2. This voltage will permit the use of incandescent lamps having the strongest possible filament of the most rugged construction. A complete line of 6 and 7 volt lamps has been manufactured for some years past for automobile service. No new sizes need be developed for locomotive service, except that the size and form of filament winding in the headlight lamp will have to be changed slightly to give the proper distribution of light.

3. This voltage will permit the use of a small storage battery on the locomotive, if so desired. Sufficient space is not now available on steam locomotives for 32-volt storage batteries.

4. This voltage can be obtained from a small turbo-generator as readily as any other voltage.

Candle-power.

The Columbus tests show that an incandescent lamp of approximately 50 mean horizontal candle-power will give sufficient light to meet the recommended maximum requirement of 3000 apparent beam candle-power. Concentrated filament tungsten lamps are now regularly manufactured in candle-powers of 50, 100 and 160 at 6 and 7 volts, for headlight service. The two larger sizes are not deemed necessary by your committee. The specifications for the lamps your committee would recommend are:

For Use in the Headlight.

Fifty candle-power, 7 volt, G-20 clear bulb, Edison screw base (style 100), loop-back tungsten filament, multiple burning, headlight lamp.

(In case gas-filled lamps are used, the filament winding should be of such form and shape as to correspond closely with the form and shape of filament used in the lamp above described, and "gas-filled" must be specified when ordering.)

For Use in Cab, Markers, Etc.

Six candle-power, 7 volt, G-10 clear bulb, double-contact bayonet candelabra base (style 1000), tungsten filament, multiple burning lamp.

Socket.

Standard double-contact bayonet sockets are recommended for bayonet base lamps. Standard Edison screw sockets, equipped with Benjamin lamp grip, or equivalent, are recommended for use with the headlight lamp.

Reflectors.

When metal reflectors are used, the minimum nominal diameter should not be less than 16 in. When parabolic glass reflectors or semaphore type lenses are used, the minimum nominal diameter should not be less than 12 in.

Method of Photometering.

In last year's report your committee described in detail the apparatus and method used in the Columbus tests for photometering headlights, and on page 780 of the report they recommend that apparatus, conforming in all details to that used at Columbus, shall be used in future investigations of this nature. This apparatus is somewhat cumbersome, however, and requires that a permanent location and considerable floor space be given to it. As shop space is usually very valuable, your committee is of the opinion that a device of this kind will not find extensive use. A photometer table, constructed entirely of metal, has been developed along somewhat different lines, which, it is thought, will be more readily adaptable to railway service. This table is so designed that it may be readily handled or moved about, and may be set up in any location where sufficient floor space is available.

This table is shown in Exhibit "A." It consists of a platform (a) on which the headlight is mounted. This platform (a) is adjusted vertically by a screw (b) until the axis of the headlight corresponds with the point (c). The platform (a) and its adjusting-screw (b) are supported by a cradle (d), swinging in a vertical plane above a horizontal axis through the point (c), the whole being supported by a "U" frame (e) of steel tubing. The "U" frame (e) is in turn supported by and rotated horizontally on a metal base (f), provided with adjusting-screws for leveling. The platform (a) may be rotated about three degrees in either direction for finding the optical axis of the headlight. The scale (g) indicates the vertical angle and the scale (h) the horizontal angle through which the headlight is rotated. Both of these scales should be provided with verniers for accurate reading.

Space not less than 9 ft. wide by 9 ft. high and 30 ft. or more in length, depending upon the type of headlight to be photometered, must be provided and enclosed on all sides with light, tight material. Heavy canvas or oilcloth may be used for this purpose, and all interior surfaces must be painted dull black to avoid reflection. A candle-foot photometer is mounted at one end and the headlight table at the other end of the room. Between these a series of at least three canvas screens, painted dull black on both sides, should be attached to the ceiling, floors and walls. A hole approximately 1 ft. square should be cut in each screen on the axis of the headlight. The candle-foot photometer is mounted outside

the photometer room, the milk-glass tube projecting through the end wall on the horizontal axis of the headlight.

The headlight should be set up at the following distances from the milk glass of the candle-foot photometer, depending upon the apparent beam candle-power of the headlight, as follows:

Apparent beam candle-power of headlight.	Distance of headlight from milk glass of candle-foot photometer.
1000 or less	15 ft.
1000 to 10,000	25 ft.
Above 10,000	50 ft.

The method of measuring this distance for parabolic reflectors, semaphore type of lenses, or inverted semaphore type of lenses is shown on Exhibit "B." Readings are taken by rotating the headlight, both vertically and horizontally, to throw on the milk glass of the candle-foot photometer those rays of light corresponding to the reading stations recommended in last year's report.

Since the publication of the Headlight Committee's report the following State laws have been passed or amended or rulings of State commissions have been made covering the subject of locomotive headlights:

Missouri — 1913.

MISSOURI.

SENATE BILL No. 458.

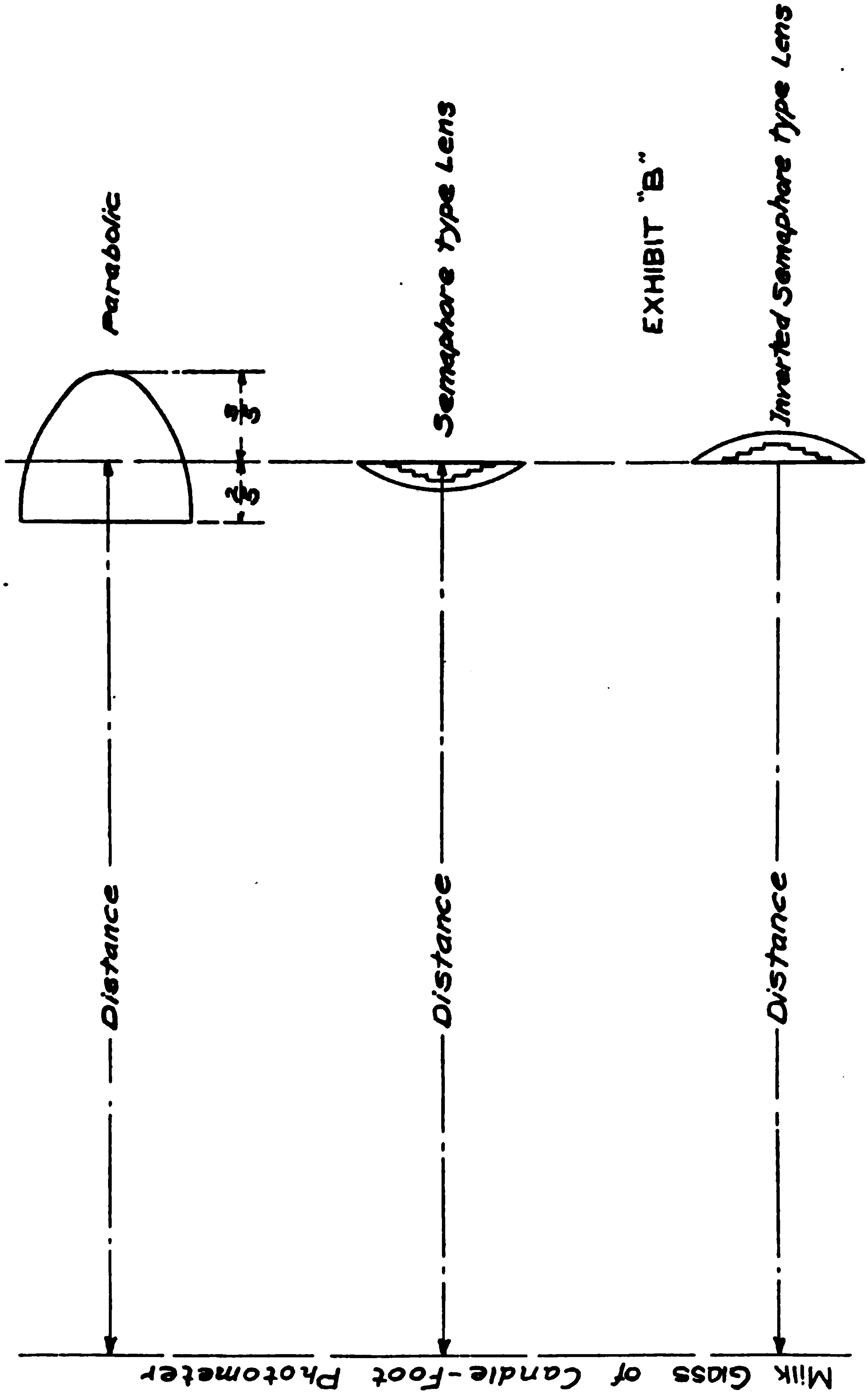
FORTY-EIGHTH GENERAL ASSEMBLY.

Introduced by Senator Moore.

An Act to amend Section 1 of an Act of the General Assembly of Missouri, entitled "An Act relating to the safety of employes and other persons on railroads by providing for electric headlights on all engines operated in road service in the night time, with a penalty for a violation thereof," approved March 29, 1913, by inserting after the word "defect" in the thirteenth line and before the word "and" in the fourteenth line of said Section 1, the following words: "But nothing in this Act shall relieve any such company, corporation, lessee, owner, operator or receiver of any railroad or railway company of any liability for injury or damage to persons or property, or for the death of any person, caused by proceeding with an engine having such defective headlight," with an emergency clause.

Be it Enacted by the General Assembly of the State of Missouri, as follows:

Section 1. That Section 1 of an Act of the General Assembly of Missouri, entitled "An Act relating to the safety of employes and other


Parabolic
Semaphore Type Lens
EXHIBIT "B"
Inverted Semaphore Type Lens
Distance
Distance
Distance
Milk Glass of Candle-Foot Photometer

persons on railroads, by providing for electric headlights on all engines operated in road service in the night time, with a penalty for a violation thereof," approved March 29, 1913, be and the same is hereby amended by inserting after the word "and" in the fourteenth line of said Section 1 the following words, "But nothing in this Act shall relieve any such company, corporation, lessee, owner, operator or receiver of any railroad or railway company of any liability for injury or damage to persons or property, or for the death of any person caused by proceeding with an engine having such defective headlights," so that said Section 1, when so amended, shall read as follows:

Section 1. That all companies, corporations, lessees, owners, operators or receivers of any railroad or railway company operating a railroad or railway, in whole or in part in this State, are hereby required to equip, maintain and use upon every locomotive being operated in road service in this State in the night time, an electric headlight of 1500 candle-power brilliancy, measured with the aid of a reflector, and classification signals not less than six candle-power; Provided, that nothing in this Act shall be so construed as to prevent a locomotive engine whose headlight has become defective while on the road, from proceeding to the most convenient terminal or division point where the necessary facilities exist for remedying such defect; but nothing in this Act shall relieve any such company, corporation, lessee, owner, operator or receiver of any railroad or railway company of any liability for injury or damage to persons or property, or for the death of any person, caused by proceeding with an engine having such defective headlight; and provided further, that the provisions of this Act shall not apply to independent lines of railroad less than seventy-five miles in length; and provided further, that the provisions of this Act shall not apply during the first ninety days of a strike of the particular employes whose duties are to repair and maintain electric headlights.

Section 2. The operation of trains with defective headlights in the night time being extremely dangerous to employes and persons on the tracks and at public road crossings, and to persons on the trains, and it being necessary not to relieve any such company, corporation, lessee, owner, operator or receiver of any railroad or railway company of any liability aforesaid resulting therefrom, creates an emergency within the meaning of the Constitution, and this Act shall take effect and be in force from and after its passage.

Approved by Governor, March 23, 1915.

Effective June 18, 1915.

New Mexico — 1915.

STATE OF NEW MEXICO.

CHAPTER "LAWS OF 1915."

House Bill No. 75 — Now Law.

An Act requiring railroads operating in New Mexico to equip locomotives used in transportation of trains over their respective lines of railroad, of sixteen miles or over in length, with headlights which will enable the engineer to see an object the size of a man at a distance of not less than 800 ft., prescribing penalty for violation thereof, prescribing the duty of the State Corporation Commission with reference to lodging information as to violations with district attorneys, defining knowledge of railway companies as to acts of its officers or agents in prosecuting under said law, and prescribing the duty of the Attorney General in reference to the enforcement of said law, under certain conditions, and for other purposes.

Be it Enacted by the Legislature of the State of New Mexico:

Section 1. That it shall be the duty of every railroad corporation, receiver or lessee thereof, operating any line of railroad in this State, on or before January 1, 1916, to equip all locomotive engines, when in use in the transportation of trains over said railroad, with headlights which, with the aid of a reflector, will enable the engineer on such locomotive to see an object the size of a man at a distance of at least eight hundred (800) ft.; Provided, this Act shall not apply to locomotive engines which are regularly employed in yard service, known as switch engines, nor to any railroad less than 16 miles in length, and provided further, that this Act shall not apply to engines now used by any railroad company operating in New Mexico which are used only in cases of emergency or exceptionally heavy traffic on short lines or branch lines, and upon which the expense of equipping said engines with headlights, as herein provided, would not be justified in the opinion of the State Corporation Commission on account of the small value of such engines.

Sec. 2. Any railroad company, or the receiver or lessee thereof, doing business in the State of New Mexico, which shall violate the provisions of this Act, shall be liable to the State of New Mexico for a penalty of not less than one hundred dollars ($100) nor more than one thousand dollars ($1000) for each and every locomotive engine not so equipped, counting each train handled by such locomotive a separate and distinct offense; and such penalties shall be recovered and suit brought in the name of the State of New Mexico, in a court of proper jurisdiction, in any county in or through which such lines of railroad may be operated.

Sec. 3. It shall be the duty of the State Corporation Commission to lodge with the proper district attorneys information of any such violation as may come to its knowledge.

Sec. 4. In all prosecutions under this Act the railway company shall be deemed to have had knowledge of all acts of its officers or agents.

Sec. 5. In case of the failure of any district attorney to bring such suit within a reasonable time after information shall have been lodged with him, by the State Corporation Commission or any other person, of any violation of this Act, it shall be the duty of the Attorney General, upon being informed of such fact, to cause such prosecution to be commenced.

Approved by Governor, March 10, 1915.
Effective January 1, 1916.

Virginia — 1914.

STATE OF VIRGINIA.

"CHAPTER 89 — LAWS OF 1914."

Senate Bill 33 — Now Law.

An Act requiring all railway corporations or receivers or lessees operating a standard-gauge line of railway in this State, to equip its locomotive engines with electric headlight, or other headlights of not less than 500 candle-power, with the aid of a reflector, and providing a penalty for violation of this Act.

Be it Enacted by the General Assembly of Virginia:

Section 1. That it shall be the duty of every railroad corporation, or receiver or lessee thereof, operating any standard-gauge line of railroad, as a common carrier, in this State, to equip and maintain in all locomotive engines used in the transportation of trains over said railroads, with electric headlights, or other headlights of not less than 500 candle-power, with the aid of a reflector. Provided, that only one-third of said locomotives not now equipped shall be required to be so equipped or used within six months after the passage of this Act; and provided further, that the remainder to be equipped within twelve months after the passage of this Act. In case of unavoidable accident to any such headlight between terminals, such train may proceed to its next terminal without violating this Act.

Sec. 2. Any railroad company, corporation, or the receiver or lessees thereof, operating a standard-gauge railroad in this State, violating the provisions of this Act, shall be guilty of a misdemeanor and fined not less than $25 nor more than $100 for such offense; and the use of any locomotive engine without the light provided for in Section 1 of this Act shall constitute a separate offense for every day or part of day so used. Prosecutions under this Act may be made by the attorney for the Commonwealth in any court of competent jurisdiction in any county or corporation in or through which the line of such offending railroad may extend.

Sec. 3. The provisions of this Act shall not apply to any railroad whose main line is not over thirty miles in length.

Approved by the Governor, March 13, 1914.

Vermont — 1915.

RULING No. 334 OF THE VERMONT PUBLIC SERVICE COMMISSION.

Therefore, it is Ordered, That every railroad corporation doing business within the State shall equip, maintain and use upon its locomotives, operated within the State, excepting locomotives used exclusively in yard service and locomotives operated exclusively during the period from one hour before sunrise to one hour after sunset, headlights of not less than 2500 apparent beam candle-power, when measured with the aid of a reflector, rated in accordance with the average of the center readings between 500 and 1000 feet ahead and upon a reference plane three feet above the rails; and shall equip, maintain and use upon all locomotives operated within the State cablights of sufficient intensity to plainly illuminate the air, water and steam gauges and to permit the reading of orders thereby.

This order shall become and be effective on and after April 1, 1915.

Dated at Brattleboro, County of Windham, this 26th day of December, 1914.

ROBERT C. BACON,
WM. R. WARNER,
PARK H. POLLARD,
Public Service Commission of Vermont.

Office of Clerk. Filed December 31, 1914.
Attest: NEIL D. CLAWSEN, *Clerk.*

It will be noted that the law of Virginia and the ruling of the Vermont Commission are in accordance with the recommendations of the Headlight Committee.

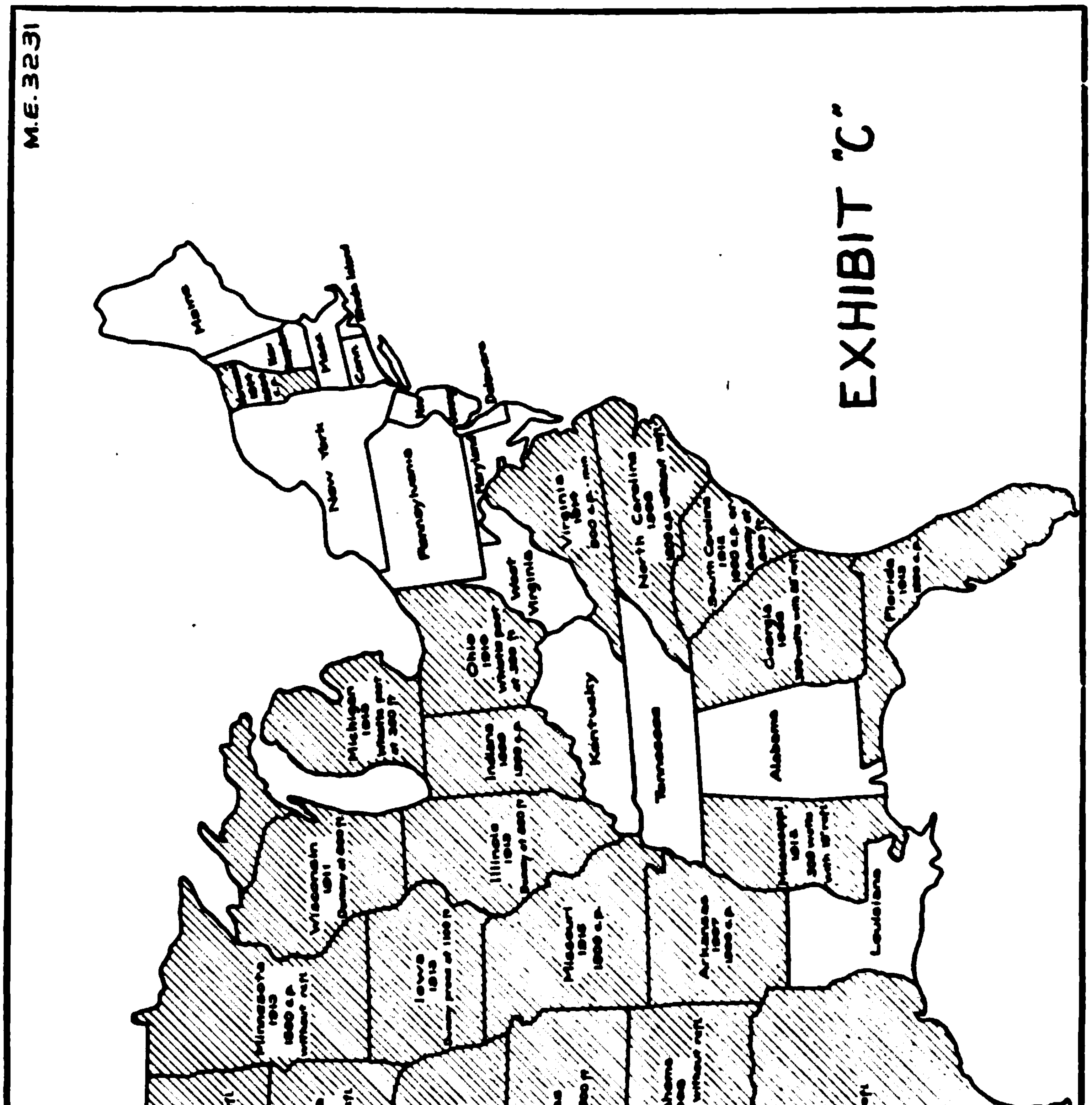
On exhibits attached to this report it will be noted that the State of South Dakota is shown as having a headlight bill, passed in 1911, requiring a headlight with 1500 candle-power without the aid of a reflector. We beg to state that we have received advice from the State authorities of South Dakota to the effect that the so-called Electric Headlight Bill was referred to the people of South Dakota at the November election, 1912, with the result that 93,136 people voted to repeal the law, as against only 20,523 voting to retain it.

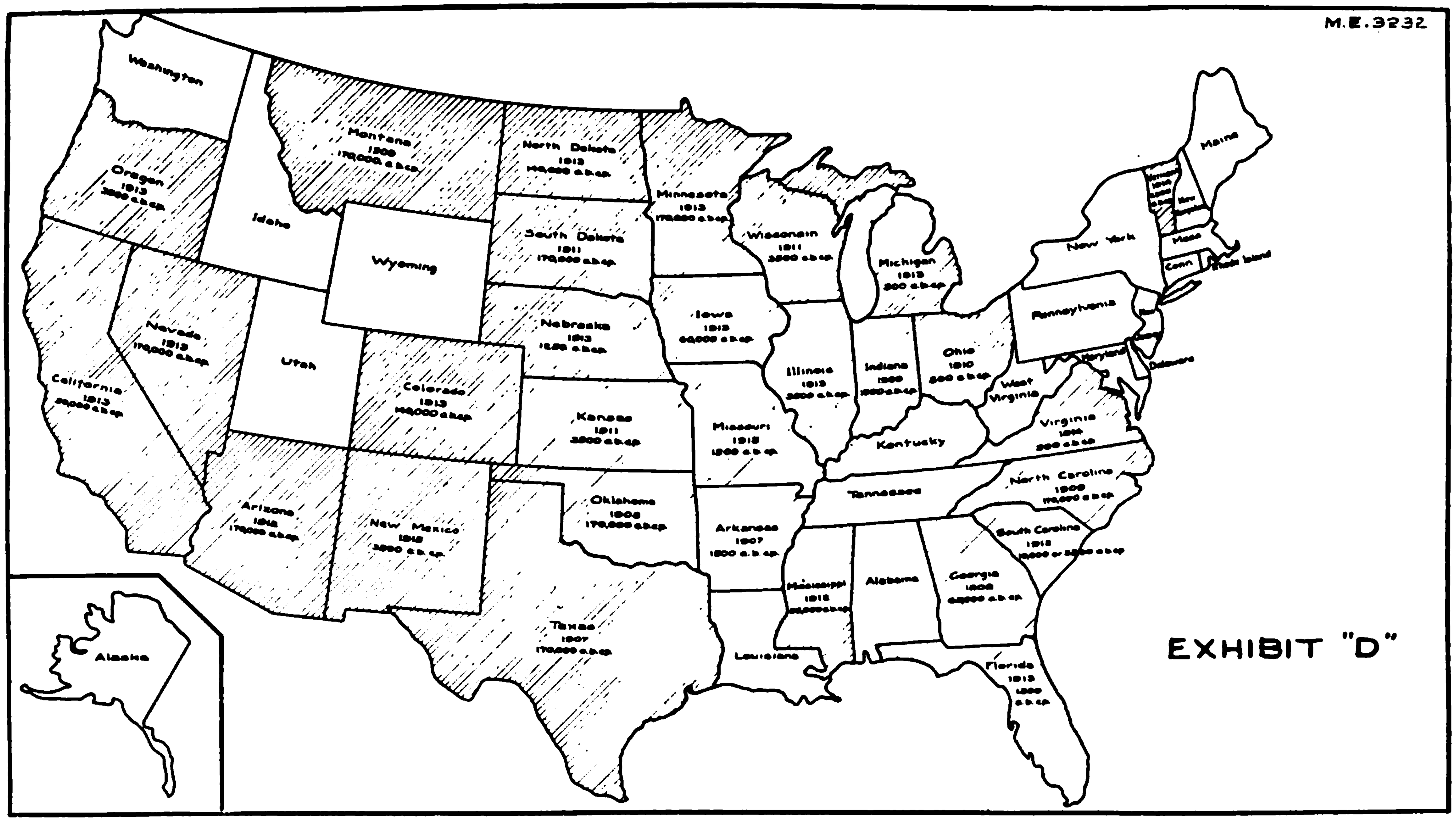
As a matter of general information your committee has added Exhibits "C," "D," "E" and "F," as follows:

Exhibit "C" is a map of the United States showing briefly the requirements of the several States, as expressed in the State laws or by rulings of State commissions.

Exhibit "D" is a map of the United States showing the requirements of the different States, reduced to the equivalent apparent beam candle-power of an oil-lighted headlight, that is, the apparent beam candle-powers shown are the intensities of light required by the various States on an oil-lamp basis.

Exhibit "E" is based upon the Columbus tests, and shows the ratio


M.E. 3231
EXHIBIT "C"
Maine
Mass.
Conn.
Rhode Island
New York
Pennsylvania
Delaware
Maryland
Virginia
West Virginia
North Carolina
South Carolina
Georgia
Florida
Ohio
Michigan
Indiana
Kentucky
Tennessee
Alabama
Mississippi
Illinois
Wisconsin
Louisiana
Missouri
Arkansas
Iowa
Minnesota
North Dakota
South Dakota
Nebraska
Kansas
Oklahoma
Texas
Montana
Wyoming
Colorado
New Mexico
Idaho
Utah
Arizona
Washington
Oregon
Nevada
California
Alaska


M.E.3232
EXHIBIT "D"
Washington
Oregon
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Idaho
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South Dakota
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Indiana
Ohio
Kentucky
Tennessee
Mississippi
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Rhode Island
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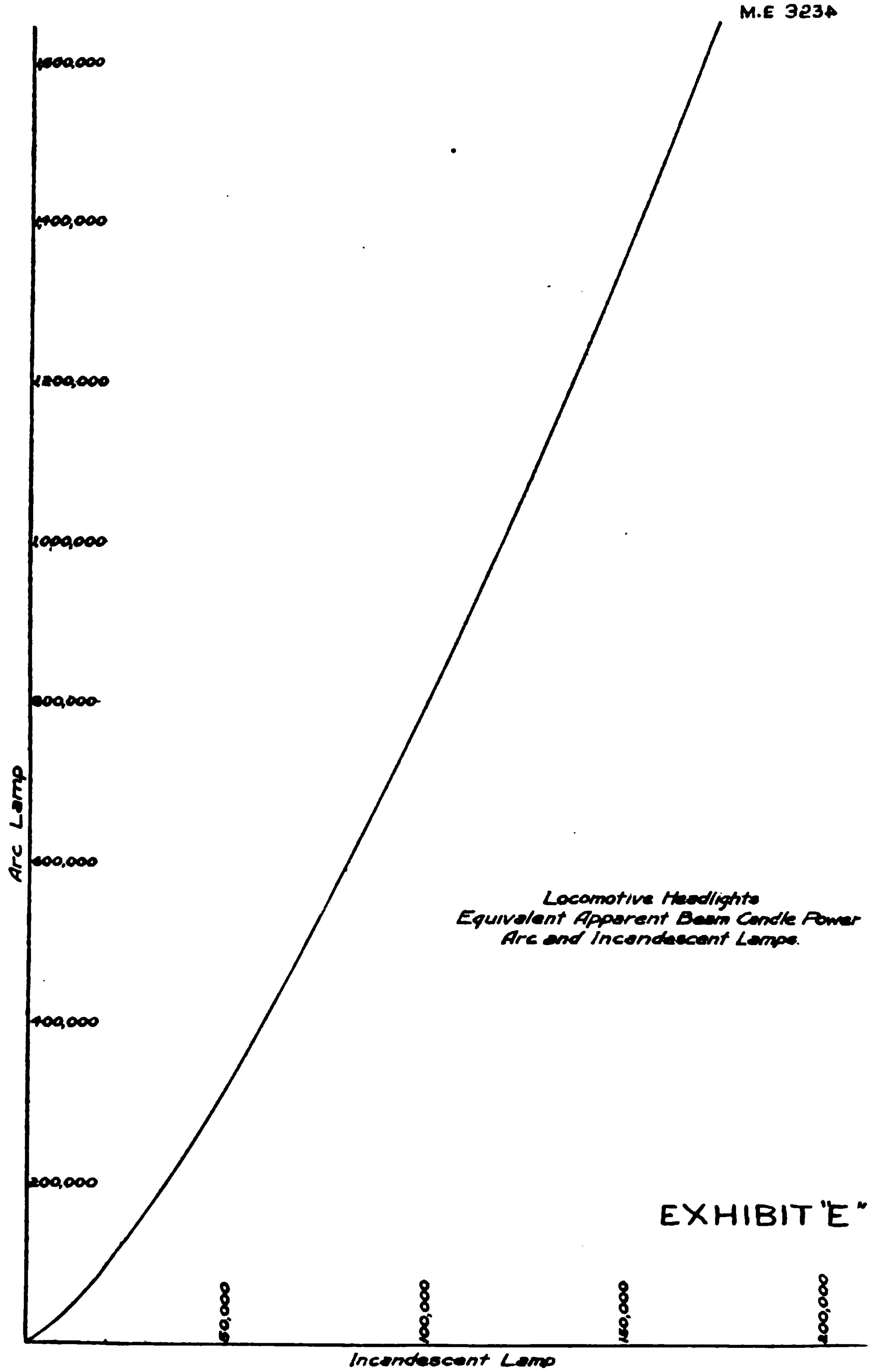

M.E 3234
1600,000
1400,000
1200,000
1000,000
800,000
600,000
400,000
200,000
Arc Lamp
Locomotive Headlights
Equivalent Apparent Beam Candle Power
Arc and Incandescent Lamps.
EXHIBIT "E"
50,000
100,000
150,000
200,000
Incandescent Lamp

15000

12500

10000

7500

5000

2500

existing between arc and incandescent-lamp headlights. Referring to Exhibit "E," any object that may be seen with an arc headlight of 800,000 apparent beam candle-power may be seen just as readily with an incandescent-lamp headlight of only 100,000 apparent beam candle-power.

Exhibit "F" is also based on the Columbus tests. All of the curves indicating dangerous conditions, as referred to in last year's report, have been reduced to a common scale and plotted on one sheet. The cross-sectioned space is the "danger" zone and the clear space is the "clear" zone. In selecting a safe headlight it is evident that its apparent beam candle-power value must lie within the clear space.

In connection with House Bill No. 509, brought up in the State of Alabama, Mr. C. H. Rae, Assistant Superintendent Machinery, Louisville & Nashville Railway, has prepared a pamphlet setting forth in excellent shape the status of the said headlight laws, and bringing out prominently the hazards to be encountered in the use of high-powered headlights. Your committee, after a thorough discussion of this pamphlet, is in thorough accord with Mr. Rae and gave its endorsement to this pamphlet.

The Sixty-third Congress passed an amendment to the Locomotive Boiler Inspection Bill, approved by the President March 4, 1915, reading as follows:

An Act to amend an Act entitled "An Act to promote the safety of employes and travelers upon railroads by compelling common carriers engaged in interstate commerce to equip their locomotives with safe and suitable boilers and appurtenances thereto," approved February 17, 1911.

Be it Enacted by the Senate and House of Representatives of the United States of America, in Congress Assembled:

That Section 2 of the Act entitled "An Act to promote the safety of employes and travelers upon railroads by compelling common carriers engaged in interstate commerce to equip their locomotives with safe and suitable boilers and appurtenances thereto," approved February 17, 1911, *shall apply to and include the entire locomotive and tender and all parts and appurtenances thereof.*

Sec. 2. That the chief inspector and the two assistant chief inspectors, together with all the district inspectors, appointed under the Act of February 17, 1911, shall inspect and shall have the same powers and duties with respect to all parts and appurtenances of the locomotive and tender that they now have with respect to the boiler of a locomotive and the appurtenances thereof, and the said Act of February 17, 1911, shall apply to and include the entire locomotive and tender and all their parts with the same force and effect as it now applies to locomotive boilers and their appurtenances. That upon the passage of this Act all inspectors, and applicants for the position of inspector, shall be examined touching their qualifications and fitness with respect to the additional duties imposed by this Act.

Sec. 3. That nothing in this Act shall be held to alter, amend, change, repeal or modify any other Act of Congress than the said Act of February 17, 1911, to which reference is herein specifically made, or any order of the Interstate Commerce Commission promulgated under the safety appliance Act of March 2, 1893, and supplemental Acts.

Sec. 4. That this Act shall take effect six months after its passage, except as otherwise herein provided.

Approved March 4, 1915.

It is evident from the foregoing that this subject will be active for several years to come. For this reason the committee feels that it should be continued so as to collect for ready reference any new information that may develop or conduct any tests that may be desired.

D. F. Crawford, Chairman,
M. H. Flynn,
C. H. Rae,
F. A. Torrey,
H T. Bentley,
M. K. Barnum,
Henry Bartlett,
Committee.

Mr. Minick: I may say that in ordering incandescent lamps it is essential that a complete description be given. All of the items mentioned in this report should be given in the sequence used. This is to insure that the requisition will not be returned to the purchaser for additional information, thus delaying the manufacture and delivery of the lamps.

Exhibit C is a map of the United States showing the States that have legislation or rulings of Railway Commissions bearing upon this subject. In each case a brief statement of the requirement is given. Exhibit D is a similar map in which the several State requirements have been reduced to a common basis, that of apparent beam candle-power. There are probably several discrepancies on this map due to the fact that some of the State requirements are so indefinitely expressed that the committee could only approximate roughly the equivalent apparent beam candle-power.

Exhibit E shows the relation existing between the apparent beam candle-powers of headlights lighted with arc and incandescent lamps. I am sorry that the cut does not show the cross-

sectioning better. It will be noted, however, that an arc-lighted headlight of approximately 1,000,000 apparent beam candle-power, and this is roughly the candle-power value of the higher candle-power arc light equipments, can be duplicated, so far as enabling the enginemen to see an object on the track at a fixed distance is concerned, by an incandescent lamp headlight of only about 110,000 to 115,000 apparent beam candle-power. In other words, an arc lamp headlight will require approximately eight to ten times as much light as is required in an incandescent lamp headlight in order to enable the engineman to distinguish an object at a fixed distance along the track.

This has not only been confirmed by the Columbus tests and other check tests, but I believe also in one of the western States which adheres to the "1500 candle-power without a reflector" requirement. A demonstration was made before the Public Service Commission and when it was found that an object could be seen with an incandescent lamp outfit operated from a storage battery, at distances slightly greater than with an arc lamp equipment, the use of the incandescent lamp outfit was authorized by the Commission. That incandescent lamp outfit, I understand, had about ten per cent the apparent beam candle-power of the arc lamp outfit.

Exhibit F is a plot of all the so-called "danger" curves produced in last year's report of this committee. The space with cross hatching is "danger zone" while that without is "safety zone." In order that a headlight may have values within safe limits its apparent beam candle-power must lie within the space without cross hatching.

The United States Congress during the last session amended the Interstate Commerce Laws by placing within the control of the Chief Locomotive Boiler Inspection Bureau, "The entire locomotive and tender and all parts and appurtenances thereof." Whether this will have the effect of wiping out all State laws and Railway Commission rulings, remains to be seen.

I will be glad to attempt to answer any questions that may be asked.

THE PRESIDENT: Gentlemen, you have heard the report. It will be in order to receive and open the report for discussion.

Mr. Tollerton: I move that it be received and opened for discussion.

Motion put to vote and carried.

Mr. Artherton (Nat. Carbon Co.): If there is no objection I should like to ask one question.

The Secretary: Are there any objections, gentlemen, to Mr. Artherton talking on this subject?

Mr. Barnum: Mr. President, I move that he be given the privilege of the floor.

Motion seconded, put and carried.

Mr. Artherton: In the matter of the storage battery in use with these incandescent lamps on locomotives I merely wanted to ask if the committee had given consideration to the use of the so-called multiple dry battery put up in unit cases for this purpose. I do not want you to think for a minute that I am prejudiced one way or the other, because our company makes both storage and dry batteries, so we can sell either one; but a storage battery is more or less of a proposition to take care of. It is an expensive thing; there are cases, however, where you can not get along with any other kind of energy, in automobile service, for example. In the illumination of motor boats, it has been found very advantageous to use the dry battery put up in cases. The dry battery put up in this way will give you from fifteen to twenty per cent longer life than a dry battery put up in individual cells loose.

This is merely a matter that I would like to have brought before the committee for information. I think that in many cases by the use of such an arrangement as this it will save considerable money over the cost of maintenance and interest and depreciation on a dry battery.

Mr. Barnum: Mr. President, the committee did not attempt to go into minute details, especially as to the consideration of different kinds of apparatus. Their thought was to handle the subject on general principles and to give their findings in the form of general rules, rather than to attempt to go into much detail or to make extensive comparisons between the different systems

of applying the light. That may be a desirable thing for the committee to do later, if it is continued.

THE PRESIDENT: Might I ask, have you tried the application of the incandescent lamp to the old arc outfits in any of your tests?

MR. BARNUM: I think Mr. Minick can answer that better than I.

MR. MINICK: Mr. President, the equipment used consisted entirely of new reflectors. They were manufactured by several firms and my recollection is that no attempt was made to use an incandescent lamp in a reflector formerly used with an arc lamp. However, incandescent lamps were used in reflectors formerly used with oil lamps, which gave very reasonable results. You are probably all more or less familiar with the 16-in. headlight used as standard by the Pennsylvania Railroad and you know that the reflector has quite large openings for illuminating the number plate. The holes for the lamp and chimney are also quite large. It was found that by closing the number holes the apparent beam candle-power could be increased about fifty per cent and by closing all holes it could be increased by more than one hundred per cent when using an incandescent lamp instead of an oil lamp.

MR. BARNUM: Mr. President, I think it might be well to get an expression of opinion from the members as to the future work of this committee. The committee has proceeded on lines which they originated and have followed without very much suggestion so far.

THE PRESIDENT: I think a motion to that effect will be in order.

MR. FULLER: Mr. President, I move you that this committee be continued. I know this is a special committee, but I think it should be continued for another year at least, and I make that as a motion.

Motion seconded, put and carried.

THE PRESIDENT: I think the committee should go into a little more detail as to just how to accomplish the results they have found. So far they have told us what can be done, but the details themselves have not been very numerous.

Mr. Minick: Mr. President, I would like to add a word of explanation. Since coming to Atlantic City there has been some question raised concerning the possibility of developing a small turbo-generator for operating six or seven volt electric headlights. There are about two million six-volt starting and lighting generators used in automobile service. As these generators are about the size that would be used in headlight outfits, it seems that this should be sufficient guarantee of the successful design of the electric end of the outfit. There are many turbines of five hundred to a thousand watts, used in headlight and other service, and apparently they are working satisfactorily. It remains to secure a somewhat smaller turbine to drive a six-volt generator of from one hundred to three hundred watts. The chief difficulty will come in properly reducing the size of the steam nozzle, and with so many turbines of slightly larger size already in service should not be a matter of extreme difficulty.

The mechanical strength of the tungsten filament lamp has also been questioned. The mechanical strength of the filament is proportional in some degree to the diameter of the filament. As the voltage of the lamp decreases, the filament diameter increases, so that in the six-volt lamp we should have an exceptionally strong filament. With two million automobiles fitted for electric light there will be probably ten million six-volt lamps in service which will mean an annual consumption of at least that number of lamps. The manufacture of this number of six-volt lamps per year should be sufficient to guarantee the quality of the product.

Mr. Dunham: In looking over Exhibit C and noting the number of States that now require the fifteen hundred candle-power lamp, and presuming that the railroads are complying with the regulations of these States, it would seem as if there are a great many equipments now on our locomotives which it would not be desirable to throw away. If the proposition is put up to us of changing to the six-volt equipment, and abandoning our thirty-volt equipment, I believe we would have a hard time to convince those who handle the pocketbooks of the railroads that this is a desirable thing to do.

The statement is made on page 2: "Lamps in the 25-24-volt class, of the proper candle-power for this service, are not now

made, and they will be difficult to develop." We on the North Western Railway have been experimenting with lamps of that kind, and every time we get a few of them and try them out on the locomotive, the engineer says, "Don't go back to the arc light." He wants to keep the incandescent lamp. We also get good service out of it. There are not so many in my territory, but there are a few, and I have talked with a great many engineers running behind the lamps of the thirty-volt size. It seems as if we will be able to get good material in these lamps, and also get good results without changing the generators or any other part of our present equipment on the locomotive.

MR. BARNUM: Most of the points which Mr. Dunham has made are good. It was not the intention of the committee to suggest discarding the present electric light equipments, but only to work toward what seems to be the best practice for future installations.

It is quite probable that a plan can be worked out by which the present equipment can still be used in connection with lower voltage if desired; and if not desired, there is nothing to prevent continuing the present equipments in use as they are.

THE PRESIDENT: Do you not think it would be a good idea for the committee to take up that phase of the subject? A lot of roads have high-power headlights. They do not want to throw them away, but still they think they are too high powered. I understand there is an arrangement by which you can cut them down, and I think it would be valuable work for the committee to consider that feature.

MR. MINICK: The committee has not made the statement that thirty-two-volt headlight lamps are not made. They state that lamps of the proper candle-powers for use in the cap and classification lanterns are not now regularly made in the 25-34-volt class. Headlight lamps of 50, 100 and 160 candle-power are made in both the 6-7-volt and 25-34-volt classes. These latter may be substituted for the arc lamp in the headlight, but when it comes to lighting the cab, markers, etc., it will be necessary to either create a completely new and special line of lamps for this purpose or to use lamps that are too large for the service. From

an economical standpoint I do not believe any one wishes to use lamps too large for the service, unless temporarily until the thirty-two-volt service can be discontinued.

MR. PRATT: We are buying for cab lights and markers thirty-two-volt lamps, which cost 11 cents each, and I should not think that those lamps could be made to order at that price.

MR. MINICK: What is the candle-power?

MR. PRATT: About 25 watts.

MR. MINICK: That will run about twenty-one candle-power, and only five to eight candle-power is necessary. Five to eight candle-power in the proper reflector will give equally good results.

MR. PRATT: About what lights are you talking.

MR. MINICK: Cab lights.

MR. PRATT: We do not use reflectors.

MR. MINICK: You should, to make proper use of the light you generate.

MR. PRATT: Perhaps I do not know what a cab light is for — to shine in the engineer's face? Our trouble has been that the men want too much light in the cab, and we believe it is a bad thing to have too strong a light in the cab.

MR. MINICK: It depends upon where light is used in the cab. Good light is required for both the steam and air gages. In our electric service we find that a 3/8 candle-power lamp will give sufficient light for the air gage. Why use twenty-one candle-power? It may be desirable to have a light over the engineman's head with separate switch control as an emergency lamp for reading time-tables, etc. A five to eight candle-power lamp with the proper reflector is all that is necessary. It may also be desirable to have a lamp back of the apron to throw light on the coal pile. A five to eight candle-power lamp here with the proper reflector is all that is necessary.

MR. PRATT: I am not well enough acquainted with the winding of the standard generators we are using, but it would seem to me if they can not be changed readily to the lower voltage suggested, we are going to throw away a good deal of money. We have been encouraged in the use of the incandescent lamp by the

fact that it has enabled us to use some of our generators which were not reliable with the arc headlight. The arc lamp will not stand much speed variation, but when we put an incandescent lamp in the headlight the speed can vary widely and there is no special difficulty which arises on that account.

If the committee desires any suggestions for work for the coming year, personally I can think of nothing better than following up the nitrogen incandescent lamp for headlight purposes. Our enginemen who have used them, and were formerly in favor of the arc lights have changed remarkably during the past year, and they are begging for the incandescent light. An object on the track when it is once discerned, is never lost sight of, as it is with the arc light, where the bright spot travels around the electrodes.

We have hopes that the various States whose laws are so widely different, and through which are running the railroads, will change their laws, or, through the recommendation of the Federal Government, will accept the incandescent lamp headlight in place of the arc lamp headlight. I would like to ask if these standard headlights can be rewound to six volts?

Mr. Minick: It will probably cost but little more to purchase a new six-volt outfit than to rewind the thirty-two-volt, and the steam consumption would be reduced probably seventy-five per cent.

Mr. Pratt: You are not working for a headlight company.

Mr. Minick: No, sir; I am employed by the Pennsylvania Railroad.

Mr. Pratt: How many electric arc headlights have you on the Pennsylvania Railroad?

Mr. Minick: We do not have any.

Mr. Pratt: We have a great many, and we do not want to discard them and buy others.

Mr. Minick: I do not think that you grasp the purpose of this report. It was not the intention of the committee to suggest that railroads generally should discard equipment now in service. It is the intention to set a standard, and from time to time as present equipments fail or wear out, to replace them with new

equipments approaching closely to the standard that has been agreed upon. As a matter of fact all the thirty-two-volt headlight lamps necessary, in whatever sizes may be required, may be secured for the present equipment. Lamps of sufficiently low candle-power for use in cab, markers, etc., are not now regularly manufactured in the thirty-two-volt class. All of the standard lamps in this class are of too high candle-power for this service.

Temporarily it might be satisfactory to use lamps in this service that are somewhat larger than are actually required, during the period of changing from thirty-two to six volt equipment. If this practice is followed there will be difficulty in substituting the proper size of lamps in cab service when the six-volt equipment has been installed as any reduction in light will bring protests from the engine crew.

Mr. J. A. Pilcher (N. & W. Ry.): I would suggest in connection with the subject of headlights, so far as the cab lights and auxiliaries are concerned, could not these be run in series, using low-voltage lamps, and in this way keep down the power?

Mr. Minick: It is quite possible to operate lamps in series just as is done in street-car service. Two points must be kept in mind, however: first, that the manufacturer of the lamps must be requested to select them for their current value instead of voltage value, otherwise they will not operate satisfactorily; and second, when multiple-burning types of incandescent lamps are selected for series-burning service an extra charge, sometimes as high as 5 cents per lamp, is usually made to cover the cost of the extra inspection and handling required.

Mr. J. H. Davis (B. & O. R. R.): If the committee's recommendations are accepted, I would like to inquire how to comply with the law where it is stated that 1500 candle-power, unreflected, shall be furnished. The maximum candle-power of the lamps specified for six volts is 160 candle-power. I would like to have Mr. Minick explain to us how we can meet the requirements of the law.

The President: I will ask Mr. Fuller to answer that question. I think he is more familiar with that phase of it.

Mr. C. E. Fuller (Union Pacific R. R.): According to my

understanding it is presumed there will be a Federal law governing headlights, and if there is such a law according to the legal advice we have received, such a law will automatically wipe out all State laws, therefore there will not be a 1500 candle-power light required in any State, unless the Federal law requires 1500 candle-power. In other words, there are almost as many laws as there are States, and it is to the interest of everyone to have a Federal law that will permit a locomotive to run from one State to another without changing the headlights.

Another point in this connection is that some of the present State laws can not be complied with. This is admitted by everybody. I think the foregoing answers the question.

Mr. Davis: That is acting on the presumption we are going to have a Federal law. We appreciate it is very desirable.

Mr. Fuller: You have that law now; it is the last thing referred to in the report of the committee.

Mr. Davis: It seems to me there are many things to be said in favor of the committee's recommendations, but the question of voltage will depend on whether or not the Association approves the committee's Exhibit F. We all know that so far as the observance of signals is concerned the minimum amount of light at the forward part of the locomotive is conducive to the best observation of signals; on the other hand, so far as detecting an object on the track is concerned we want the maximum amount of light. I believe about sixty per cent of the States in the United States have passed headlight laws. In most cases, I presume, primarily these laws were enacted to require the installation of a headlight of sufficient candle-power to detect an object on the track at a given distance. In fact, the law specifies that in most cases. To comply with that feature of the law will require a powerful headlight. The requirements for the safety of the train, however, which depend upon the observation of signals, are wholly incompatible with the requirements of picking up an object on the track.

I presume the committee's recommendations, if accepted, will not be retroactive, but will simply be for our guidance in the future in the application of headlight sets.

Mr. Fuller: I want to correct a misunderstanding which appears to exist, namely, that we are going to have a Federal law. We have such a Federal law, but there have been no requirements framed under it. We presume that when these requirements are framed they will be Federal requirements, so that all the railroads in the United States will be operating under one set of requirements.

Mr. Minick: Another point is that these laws require 1500 candle-power without the aid of a reflector. What does this statement mean? Does it mean candle-power in some one direction? If so, several of the arc light equipments now in general service will meet this requirement as they give more than 1500 candle-power in one direction, but unfortunately that direction is not a useful one. Does it mean the "mean horizontal candle-power," that is, the average candle-power in a plane passing through the center of the light source at right angles to the axis of the lamp? This is the value generally used in designating the size of a lamp, as for instance "a 16-candle-power lamp." If this is what is intended, no electric lamp, arc or otherwise, now sold for headlight service will meet this requirement. The most powerful of the arc-lamp equipments will not give 1000 mean horiontal candle-power. Does it mean the average of the light given off in all directions? This is known as the mean spherical candle-power and is the basis for calculating "quantity" of light. The most powerful of the arc-light equipments will hardly exceed 600 mean spherical candle-power. If Mr. Davis will tell us which of these three kinds of candle-power are referred to, we will answer his question.

We might adopt the solution employed, it is said, by Thomas A. Edison in the early days of lighting when he started his first power plant in New York city. He was required to light the streets of New York city with arc lamps of 2000 candle-power. His lamps were installed at street intersections and as they gave 500 candle-power in the direction of each of the four streets they were said to be of 2000 candle-power.

The President: I think you are right about that as far as the 1500 candle-power without reflector is concerned.

Mr. Minick: The whole effort of this committee has been

to fix the value of the headlight in its completed or operating condition. We are interested primarily in the amount of light on the track and we do not care whether one candle-power or 1,000,000 candle-power without the aid of a reflector is used; just so we get the right amount on the track.

THE PRESIDENT: I think if you will look at the committee's report of last year you will find that they very plainly indicate how that is to be measured and in what way. Are there any further remarks? This is a very important subject.

MR. W. H. V. ROSING (St. L. & S. F R. R.): Mr. Chairman, we use the same kind and style of electric lamps in cabs, as we do in passenger-train lighting, and it seems to me that while this convention does not entertain train lighting, the locomotive and the passenger train, however, are a unit, and should be considered together. It is my opinion that by using the same lamps in both engine and train, notwithstanding the higher voltage (thirty-five volts), the possible greater expense for the locomotive would be offset by not having to carry a separate stock of lamps at different parts of the railroad where such repairs would be required. If the low voltage is desirable for locomotives, there is a question in my mind whether or not it would be advisable to use the same in passenger train cars. As I said before, as the engine and the train are a unit, and although operated by separate apparatus, it appears to me desirable to maintain the same lamp equipment for both.

THE PRESIDENT: Mr. Minick, will you reply, please?

MR. MINICK: Mr. President, there was some discussion of the use of the train lighting service for furnishing current to operate the headlight. The objection to this is that some means must be provided for making connections between the locomotive and tender and between the tender and train. Coupling devices for this purpose are usually used only with the so-called Head End System of train lighting, which is gradually going out of use. Furthermore, while the thirty-two-volt lamp is a satisfactory lamp for coach service it is doubtful whether it will stand the rough usage of locomotive service. Locomotive springs are much stiffer than those used in car service, consequently the vibration in the

locomotive to which the lamp will be subjected is quite severe and it is doubtful whether the regular train-lighting lamp will stand this service. These, I believe, were the factors considered by the committee in discussing this question.

THE PRESIDENT: I dislike to call upon Mr. Fuller so often, but I would like him to describe a little more fully the headlight equipment that is generally used; how it is operated.

MR. FULLER: I suppose everybody knows how it is operated, with simply a turbine.

THE PRESIDENT: A turbine, but it is not on the engine.

MR. FULLER: It is on the boiler. Are you talking about the train?

THE PRESIDENT: Head end train lighting.

MR. FULLER: The head end train lighting is simply a turbine in the baggage car, or blind car, at the head of the train. Steam is furnished from the locomotive to the dynamo through the steam-heat system. We use the head end system almost exclusively for our through trains, but we are not so sure whether we would do that if we were starting into the proposition new. We are not sure but that we would go to either the axle device or possibly some other system. The head end system for transcontinental trains is the cheapest lighting system, provided it is not necessary to go to the expense of carrying a train electrician. In such case it runs the cost up. Our baggagemen are paid an increase of salary and perform the functions of a train electrician successfully. I believe the Northern Pacific Railway is departing from this practice, and have two or three trains running with the axle device. For such roads as are not using electric light for their passenger cars, it is questionable whether they would be wise in going to the head end system, especially the steam turbine, for the reason that it is necessary to keep the trains together and all cars cabled, and where roads are running a lot of Pullman cars it is the universal practice to use the axle device. Therefore on such trains it results in a double set of equipment, increasing the cost, whereas one system should be sufficient for the entire train.

MR. BARNUM: Mr. President, I would like to again call the attention of the members to the wishes of the committee to receive

suggestions for the work next year, and to assure them all that any suggestions which are sent to the Secretary will receive careful consideration and will be very much appreciated.

THE PRESIDENT: That would be a very good idea. Anybody who has any ideas along those lines please send in your communications to the Secretary and do it early; do not put it off until June. Is there any further discussion on this subject?

MR. D. D. ARDEN (Sav. & Statesboro R. R.): Do you not think, Mr. President, that it would be well to work on the reflector just as well, so as to reduce the power by the use of proper reflection?

THE PRESIDENT: I think that is a very pertinent comment to send to this committee.

MR. BARNUM: Mr. President, I move that the discussion be closed, and that we proceed to the next subject.

Motion put, seconded and carried.

THE PRESIDENT: The next subject is the report of the Committee on Design, Construction and Inspection of Locomotive Boilers. Mr. Fuller, S. M. P., Union Pacific R. R., is chairman.

The report above referred to was thereupon read by Mr. Fuller, as follows:

REPORT OF COMMITTEE ON DESIGN, CONSTRUCTION AND MAINTENANCE OF LOCOMOTIVE BOILERS.

To the Members:

While the scope of the committee, according to the title, covers design, construction and inspection of locomotive boilers, it has been found impossible, in the time available, to do more than cover what the committee feels to be the most pressing and important phase of the locomotive-boiler question, namely, a uniform method for determining stresses.

As reported by this committee at the 1914 convention, the lack of information at that time prevented the committee from presenting a definite report. During the past year the committee has made a complete investigation of the methods in vogue for figuring stresses in locomotive boilers, and as a result of Circular "C," replies have been received from 44 roads.

The replies indicate that in some essential details, such as figuring efficiency of seams, there was no variation in methods, while in other details there was at times a wide variance of assumptions. These assumptions were grouped for further analysis, enabling the committee to arrive at the majority practice of a number of representative roads. The methods of various other authorities, such as the locomotive builders and American Society of Mechanical Engineers, were also carefully investigated. The

existing requirements of the Federal Boiler Law were carefully borne in mind. As the result, your committee desires to present the following rules for determining stresses in locomotive boilers as Recommended Practice:

Rules for Determining Stresses in Locomotive Boilers.

1. Longitudinal Barrel Seams and Patches.

(a) In figuring net section of plate, use the actual diameter of rivet hole.

(b) In figuring rivet shear, use the actual diameter of the rivet after driven.

(c) In figuring stress in plate and shear in rivet, in case the barrel is not cylindrical where it joins the fire-box wrapper sheet, use the maximum diameter. Surfaces subject to bending action under pressure must be adequately braced to prevent bending stresses.

(d) When boiler shells are cut to apply steam domes or manholes, the amount of metal in flange and liner shall be equal in strength to the metal removed. When separate flange is used at base of dome, the entire net area of same shall be assumed as reinforcement. Where dome sheet is flanged direct to shell of boilers, a vertical distance of 2 in. from base of flange shall be assumed as reinforcement, using net area after rivet holes are deducted and using 28,500 lb. tensile strength per square inch as the ultimate strength, if dome sheet is welded vertically.

(e) Investigation of the strength of seams shall be along the lines of established engineering practices and formula for efficiency and strength and in accordance with paragraphs "a" and "b." Investigation of the strength of the seams by the usual engineering formula is a definite and determinable problem and there shall be no variations introduced in the usually accepted methods.

2. Longitudinal Gusset Braces and Flat Surfaces.

(a) In figuring stress in diagonal braces, allowance for the angularity of the brace shall be made.

(b) The sectional area of the brace and the strength of the attachment of the brace to the shell shall both be investigated and the lowest net strength shall be used.

(c) In determining the strength of gusset braces for supporting back head and tube sheets, use 100 per cent of rivet-bearing area, 80 per cent of rivet shear area and 90 per cent of gusset plate area, measured at right angles to the longest edge of gusset sheet, and of the three, select the minimum value.

(d) The calculation of stress in gusset braces shall cover both the section of the plate and strength of fasteners, and the lowest net strength shall be used.

(e) In figuring flat stayed surfaces, such as back heads, the boundary of the unsupported flat surface shall be located at a distance equal to outside radius of flange measured from inside of shell.

(f) No supporting value shall be assigned to the stiffness of flat plates on flat surfaces, as it is too small to be of material value.

(g) Reinforcing plates, such as back head liners, shall not be figured as having any staying or supporting value, but shall merely be considered as mechanical reinforcements for various attachments, such as longitudinal stays, staybolts, etc.

(h) The distance beyond the outer row of flues on tube sheets, assumed to be self-supporting, shall be 2 in.

(i) In calculating the area to be stayed on front tube sheet, the area of the dry pipe hole shall be deducted.

(k) Tee irons or other members, when used subject to bending, shall be calculated without addition for strength of plate, and the stress in such beam and its abutments must not exceed 12,500 per sq. in. The spacing of the rivets over the supported surface shall be in conformity with that specified for staybolts. No allowance for value of such beams shall be made in calculating the total area of longitudinal braces that may be attached thereto.

(l) Where there are a number of diagonal stays supporting a flat surface, such as back head or front tube sheet, the proportion of area allotted to each brace shall be as follows:

Divide the entire net area to be stayed by the entire net area of braces. If it is felt that any individual brace is so segregated as to receive more than its fair proportion of the load, it shall be investigated separately as to the area which it supports.

(m) Patches when applied to the barrel of a boiler shall be designed with longitudinal and circumferential seams at least equal in strength to the main longitudinal and circumferential barrel seams. Patches may be applied to flat stayed surfaces with properly designed single-riveted seams without impairing the strength of the sheet.

3. STAYBOLTS — RADIAL STAYS AND CROWN BAR BOLTS.

(a) In figuring the net area of staybolts to obtain the stress, the area of the tell-tale hole shall be deducted.

(b) When figuring area at root of thread, the area must depend upon the type of thread used, namely, United States, V or Whitworth threads, as the case may be.

(c) In determining the area for figuring stress on staybolts, the area of one staybolt shall be deducted from the rectangular area included between any four staybolts.

(d) In boilers with crown bars supported on fire-box side sheets and sling stays, the sling stays shall be considered as carrying the entire load.

Respectfully submitted,

C. E. Fuller, Chairman,
M. K. Barnum,
J. Snowden Bell,
C. B. Young,
D. R. MacBain,
A. W. Gibbs,
R. E. Smith,

Committee.

MR. BARNUM: Mr. President, I move that the report of the committee be accepted and the recommendation submitted to letter ballot.

Motion seconded, put to vote and carried.

MR. FRANEY: Mr. President, one of our members, Mr. O. M. Foster, recently met with a very sad accident resulting in a serious injury to Mr. Foster and the loss of his wife and daughter. Mr. Foster has recovered from the accident. The loss of his wife and daughter, a very promising and talented young lady, has surrounded the case with considerable sadness, has made it a very pathetic one. If consistent with the rules, I move that our Secretary be instructed to convey the sympathies of this Association to Mr. Foster.

MR. PRATT: I would like to second that motion, Mr. Chairman. Mr. Foster gave us a wonderfully thorough report last year or the year before; he took a lot of time on it, and he has been an active worker in this Association, and our hearts all go out to him at this time.

Motion seconded, put to vote and carried.

J. SNOWDEN BELL: Mr. President, prior to the discussion of the report that has just been presented, or even in the event that there be no discussion of it, it seems to me that in justice to the committee, and particularly to the chairman, whose work has been to my knowledge very laborious and painstaking, there should be a brief explanation made to the convention, of the brevity of the report; its failure to deal with the question of the design of locomotive boilers; and the amount of work that has been done by that committee, which is not even referred to in it, and of which no mention has been made.

We all know that in a great many investigations, reports that are made on investigations, a very large amount of work is done which does not show — nothing appears, and there is no showing made; and that is just the case here.

Soon after the committee organized it came to our knowledge that there was a committee of the American Society of Mechanical Engineers appointed to formulate a code of specifications for the construction of steam boilers and other pressure vessels, which naturally included air-brake reservoirs, gas tanks, etc.

The Mechanical Engineers' Committee published and sent out

very largely a voluminous preliminary report, I think it was about 250 pages in length. We also learned that this report had not been approved by the Society at all, but even in the absence of approval, that they proposed to send copies of that report to the legislatures of seven different States, with a view to guiding legislation that might be made in that direction. Upon an examination of that report it was, in the judgment of our committee, found that there were a great many very objectionable provisions contained in it in regard to the factor of safety, in reference to pressure vessels other than steam boilers, and most important, with regard to stationary boilers, a very large number of which are used by railroads.

We therefore deemed it to be most important to endeavor to obtain a modification of such of those provisions as we considered to be detrimental to the railroads, and the first thing we did was to meet with this committee. There were, I think, four different meetings which were devoted entirely to a consideration of the American Society of Mechanical Engineers' proposed code; two at New York that I attended, two at Chicago, at one of which I was present, and possibly others, but to my knowledge at least four. There was also a correspondence with the Committee on the Relation of Railway Operation to Legislation, with which our committee was naturally very closely in touch, and each of the committee was deeply interested in this subject.

Without attempting to discuss the propriety of our action in that matter, whether or not these proposed provisions of the Society of Mechanical Engineers were desirable or prejudicial, we certainly believed them to be the latter, and we believed it to be our duty to do everything in our power to obtain such modifications of them as possible.

We succeeded in doing that to a certain extent. The draft of the report which they first issued has been revised three times; and now this morning I saw the fourth revision. There have been quite important modifications. We have not obtained all we wanted to, but we have certainly made a very great improvement upon the original drafts of the reports. All of that meant a double correspondence, and the devotion of the time and labors of the committee to that particular subject, none of which, as I say, appears in the report, and which I think the convention ought to be informed of. [Applause.]

Mr. Pilcher: As I understand it, this report has been passed on and referred to letter ballot, has it not?

The President: Yes.

Mr. Pilcher: I was anxious to speak on one of these items. I do not know whether I am too late or not.

The President: Of course it is never too late.

Mr. Pilcher: Under the heading "(i)"—" in calculating the area to be stayed on front tube sheet, the area of the dry pipe hole shall be deducted."

It looks to me as if that is wrong, because while the hole is in the front sheet, the pressure coming on the pipe itself is finally delivered on that sheet around its circumference, and I would like to know just the line of reasoning the committee followed in that connection.

Mr. M. H. Haig (A. T. & S. F. Ry.): The report presented by this committee contains much valuable information that will be useful in figuring on boiler construction and alterations in the future. The parts of most boilers in service have already been figured, but there is still more to be done in the matter of repairing and reinforcement. The Proceedings of the Master Mechanics' Association are used by many besides the members of the Association. The Proceedings should serve as a guide, and the information contained should instruct those who might be assigned to boiler work in the future.

In maintaining boiler records, designing new boilers and preparing boiler reports it is necessary to train new men from time to time. It is also necessary to have understudies for this work in order to provide substitutes in place of the regular men when occasion arises. This boiler work is important and must be handled by reliable men. While men responsible for the reports check them carefully, their work is necessarily supplemented by the assistance of others who do the original figuring. Therefore, I feel that the simpler the explanations contained in the Proceedings the more useful they will be.

Item A is an example that I have in mind, which might be explained more fully. I think it would be well to show how the angularity of the brace is allowed for in figuring the stress. No doubt all members of the committee, as well as others present, understand how to figure it. The point I want to emphasize is

this: It is desirable to place copies of the Proceedings in the hands of men who calculate boiler parts and who are learning this calculation. If the information is fully explained and simply stated, these men can learn the methods readily, and placing copies of the Proceedings before such men will serve instead of giving detailed instructions.

Item E on page 3 suggests that the boundary of the unsupported flat surface shall be considered at a distance equal to the outside radius of the flange. I would like to suggest the outside radius plus one inch. I think the additional area is well taken care of by the curved surface. I do not think we should lead to any increase of the radius in order to get a larger supported area, and I believe that the radius plus 1 in. would be good practice. Very often a part of a boiler is figured as having a factor of safety very nearly 4 and an additional allowance as described might bring the figure just a little over instead of a little under 4, and I think the additional allowance is worthy of consideration.

MR. G. L. FOWLER: Mr. President and Gentlemen: A year ago when the report of this committee was presented it was announced that there were to be some investigations made during the year that might be of interest to the convention at this time. It has been my fortune to be connected with those investigations, and we have thought that it might be of some interest to present our tentative results now. I do not want them to be considered in the slightest as demonstrations. They are merely indications of what is happening in the locomotive fire box, and as the construction of the box is to a great extent dependent upon these conditions, I am taking the liberty of presenting them to you here.

The object of the investigation was to determine the relative amount of movement between the two sheets of the side water leg of a locomotive fire box, by which the amount of deflection of the staybolt in the two sheets might be determined. In addition to that we made an approximate determination of the temperatures of the two sides of the inside sheet; that is, the temperature of the sheet next to the water and of the side of the sheet next to the fire.

Of course, the work at the start was entirely without any precedent. I had absolutely nothing to go by and it was a mere matter of guess as to where we were going to land. I had looked

over some tabular work in regard to the amount of expansion due to heat temperatures and found them to be very slight, and when we were prepared to go into the work I called the boilermaker and asked him to indicate the staybolt that gave the most trouble. I want to say in the first place that the credit for this work is due to Mr. MacBain, of the Lake Shore. He supplied the two boilers for the purpose, with new fire boxes especially constructed. The fire boxes had the grates about eight feet long and five feet wide. One fire box had a complete installation of rigid staybolts 1 in. in diameter put in in the usual manner; the other had a complete installation of Tate flexible staybolts throughout. The first bolts that we tackled were in the top row at the front, the one just below the crown sheet. I had a rather amusing experience with it. My apparatus was so designed that there was no lost motion in it and it was of such a character that I could multiply the relative motion of the two sheets indefinitely, using a rotating mirror and a reflected beam of light. I started in one evening and told the fireman to go ahead and get up steam, to pay no attention to me, that I wanted roundhouse practice. I really did not know what I did want, but I told him to go ahead and get up steam exactly as he would do it in the roundhouse. He proceeded to do that. I went out to the side of the house and sat down and waited until I thought something was likely to happen. I waited about twenty minutes and went back to my apparatus to get a reading, and found that whereas my divided beam of light that carried the motion on the outside sheet was there, the other one had absolutely and utterly disappeared. It had traveled off into space somewhere, and we felt around with our hands in the darkness — the work was all done at night — and finally located it off about five or six feet, so far away that we could not get any results at all, and we called the test off for that night. The next night I moved my instrument up a little closer, so that I would get my beam under control, and then surprises began. I found that that sheet started to expand the moment the fire was kindled. When I speak about the expanding of the sheet, or say a sheet moves down or back or forward, I mean that the inside sheet moves down or back or forward relatively to the outside sheet. My whole apparatus traveled with the outside sheet — so that that can be disregarded. It is relative movement and the deflection of the

staybolt that we were after. I found to my astonishment that those sheets began to show movement and expansion within, we will say, a minute of the time that the lighted waste was thrown in to light the fire. The fire was not yet kindled. It was just simply a piece of waste burning; but the sheets began to move, and the curious thing about the performance was that they almost invariably went in the wrong direction, that is, in the unexpected direction. For example, the front upper corner of the sheet, instead of going up and forward, as we would expect it to do with the heat applied, went down and back. It did not go very far, not much more than one-thousandth of an inch; but that was the preliminary movement, back and down; and then it started up, and it kept moving and did not stop its motion at all. It was a constant movement throughout the whole proceeding. At the end of about twenty minutes it had reached its maximum forward movement. Then as the steam began to rise it went up, and while we had steam pressure on, it tied itself up into several double bow knots and then came down back practically to its original position when the boiler was blown down; but this was the case in all of the investigations throughout. In making hundreds of readings I never found two consecutive readings alike, that is, the staybolt is always in motion. It is in a regular vibration testing machine in which the bolt is always being bent backward and forward — not very much, one one-thousandth or two one-thousandths, or something of that sort, between readings, but always in constant motion, and stays pretty well deflected until we pull the fire and begin to blow down the boiler.

The ordinary method of doing the work at first was to build a fire; give no instructions whatever to the fireman, let him go ahead and do the work as in the ordinary roundhouse, and with that, of course, we got varying conditions in the way of building up steam pressure. We would carry 200 lb. pressure, which would be raised in from fifty-five minutes to an hour and a half; then I held the steam there with both pops blowing for about fifteen minutes; then dumped the fire and began to blow down the pressure through the blowers in the stack, and when that was not enough I opened the throttle a little; but I blew down at the rate of about one pound per minute, so that it took about three hours to drop the steam pressure to zero. In no instance did the

boiler come back to its original position until the steam pressure was all drawn. In some cases it did not come quite back, but in no instance did it come back to its original position until the pressure had entirely disappeared. Then in making the comparison between those two bolts, the upper corner at the front end, between a flexibly and rigidly stayed boiler, we found something that was quite astonishing, yet perhaps should have been expected. The amount of movement of the flexibly stayed boiler in comparison with the rigidly stayed boiler was as 31 to 13. That is, the maximum deflection that I found for the staybolt of a flexibly stayed boiler was .031 of an inch, and for a rigidly stayed boiler it was .013 of an inch. That ratio held practically for all of the staybolts. That was the maximum deflection that I got in any point of the boiler. Going back to the back end of the same row of bolts, of course the movement was to the back, but practically the same; then we came on to the middle bolt in the center of the boiler, where we would naturally expect to have the neutral zone. Well, there may be a neutral zone, but I failed to locate it. Of course, if you have got the back end of your boiler going back and the front going forward, there is some point in between where there is no motion, but that is only an instantaneous neutral zone. That neutral zone is varying from front to back and up and down all the time, but the limitations of the movement of that central bolt with the flexibly and rigidly stayed boiler was very marked. For example, the total horizontal motion of the rigid bolt was about .026 of an inch. The total movement of the flexible bolt was about .042 of an inch, showing that it was about twice as much. That can be taken as a fair average of the results obtained, that that of a rigidly stayed boiler only moves about half as far as that of a flexibly stayed boiler.

During this work I was going from bolt to bolt, night after night, and when I had completed the work of six bolts, that is, three on the top row and three on the middle row, I thought that I ought to go over the whole thing again, and check off, but I found on that middle row of bolts and as I came farther down, a phenomenon that at first it was difficult to explain, but which I think I discovered the explanation for later. The first movement — in fact a very serious movement of the inner sheet, at the first, was down. The funny part of it was the downward movement

increased as you approached the mud ring, and that was something, of course, that was quite preposterous. My apparatus was so designed as to measure the apparent movement of the two sheets, so that if there were a buckling of the sheets I might get a very decided downward movement, apparently, when I didn't have any at all; but I did have, of course, a bending there of the sheet, or of the stay. That is the point that has got to be taken up. I saw then that there was no use checking over with an apparatus that was weak in that particular direction, so I have redesigned it, and I am pleased to be able to say that the facilities will be afforded this fall to go into those same two boilers again with an improved apparatus that will measure not only the actual relative movement of the two sheets, but any buckling that may occur in the inside sheet.

As far as our staybolt investigation is concerned we have gotten this, I think, without any peradventure: that the staybolt is in constant motion during the whole period of the time from the boiler being cold until it is cold again; that it is always bent when it is under stress, and that the maximum deflection of the bolt occurs before any steam appears on the gage.

In addition to that I put gages in the throat sheet, in the roof sheet and in the back head, to measure the relative in and out movement of those sheets, relatively to the back tube sheets, the crown sheet, and the back sheet in the fire box.

I am sorry to say that the indicators from the throat sheet and the back head were not always very consistent, but the consistency of the movement of the crown sheet to the roof sheet was really very delightful. The very instant the fire is kindled and we begin to get any heat there at all, that crown sheet begins to go up relatively to the roof sheet. It goes up quite rapidly until the first indication of pressure appears, and then it begins to drop, and in almost every instance it dropped well below its normal position when we had reached our full steam pressure.

The other variations I think can be accounted for in another way, of which I will speak in a moment. In addition to these I made an attempt to get at the relative movement of the back tube sheet to the shell. Fortunately there was a washout plug located about three or four inches ahead of the back tube sheet. I went

in there and got hold of a tube, about three in. ahead of a tube sheet, came out through that hole and made my connections relatively to the shell and the tube. Whether the relative motion of the tube at that point was transferred en bloc to the tube sheet, I can not say, but the indications are that it was. The interesting thing there was to see the movement of that tube when we built our fire and were getting up steam. The moment that we built our fire the tube began to move back, back, back, accordingly; but I want to say, as a modification which we afterward made on our whole investigations, we took the valves out of the engine, so that I could open the throttle and drive the fire for all that it was worth for about half an hour, and with the throttle wide open, without moving the engine. When we built our fire, got up steam, that tube moved back with very great steadiness, but the very instant we opened the throttle, the tube shot back as though it were driven out of a gun. For example, my recollection is that up to the time of getting up steam, the tube had moved back to about .026 of an inch with reference to the shell, and within the next five minutes after we had opened the throttle it had moved back .042 of an inch, making a fifty per cent greater movement after the first five minutes of the opening of the throttle, than it had been during the whole period of getting up steam. Then it began to adjust itself as the boiler got hot, and came back into its original position again, at the time of reaching the steam pressure; so that after we had been driving the engine again for a little while, we were practically back to our original position. The interesting thing in regard to that is this: the figures checked, but unfortunately the dates of the investigation do not. When I was measuring in that front staybolt I said that the first movement of that sheet was to the rear. It went back .002 of an inch in ten minutes, at the end of ten minutes after the fire had been built the sheet had moved back .002 of an inch; at the end of ten minutes, after building the fire, when I had the apparatus attached to the tube, that tube had also moved back .002 of an inch, showing that the probabilities are that the first backward movement of the sheet was due to a direct thrust on the part of the tubes pushing the tube sheet back.

Then we made an attempt to get at the temperatures of the

two sides of the sheet. That was done with ordinary thermo couples, and fortunately for my own peace of mind I went up over the top of the arch for my first investigation. There I found things to be what I would consider to be practically normal; the temperature of the inside, that is, the water side of the fire box, was a little above the water temperature. My recollection is it was about 300. On the other side it was about 750. My next move with that apparatus was back toward the end of the fire box, and it apparently worked all right during the early parts of getting up steam — things were looking pretty normal, but when I got up steam I found that the fire side of my sheet was about fifty degrees colder than the water side. It did not look very good, and, of course, my first inclination was to think that the apparatus was out of order, yet it checked beautifully on the water side, and looking in at the fire door I could see nothing the matter with the fire connections, until my attention was called to the smoke tube holes in the side.

My apparatus was located about six inches ahead of the back smoke tube hole. I plugged that up and in less than two minutes my temperature was up where it ought to be, that is, the cool air coming into the tube, flowing right along on the side of the sheet, had cooled the sheet there locally until it was down below the water temperature. Then I got up above that and located the apparatus directly back of the fire door. By that time I knew I would have to look out for cool currents of air, and one evening when we were taking our readings on five minute intervals, I found that every time we took a reading there our fire side was considerably cooler than our water side. Then by taking constant readings and keeping the potentiometer balanced all the time, I could stand from twenty to thirty feet away from the engine, with the throttle wide open, both pops going, and injector running, and the fire down where it was out of sight, yet I could tell instantly when they opened it from the cooling of the sheet.

From these determinations it appears that the fire sheet is undergoing a constant change of size, due to the opening of the fire door, all of which is a pretty good argument for the use of mechanical stokers. The cool air coming in from the tubes and chilling the sheets explains the cracking which is apt to occur around these holes.

In regard to the circulation of the boiler I have very little data to offer in addition to that which we obtained a number of years ago on the circulation tests of the two boilers at Coatesville. In those tests it seemed to be pretty well shown that the water goes down to the water leg of the throat sheet, moves slowly back, and circulates just about fast enough to take care of the evaporation, but here I had only one thermometer in, and that was in the front corner in the water leg right next to the mud ring, in the washout plug, and there the temperature rose very slowly indeed. We never, under any circumstances, got a temperature to that of the steam. I think the highest temperature we registered at any one point was only 325° F., and that was when the throttle was wide open, injector running, forcing the engine to full capacity; but that is a matter I will try to take up more thoroughly in my next investigation.

I thought possibly that this information might have a bearing on boiler construction and boiler maintenance, and that the tests on the stresses to which the staybolts are subjected might be of some interest to the convention as being in the nature of what might be called a preliminary report of progress.

THE PRESIDENT: While this paper has been formally closed, yet we did not give the courtesy of the floor to the chairman of the committee to make a closure, and I ask Mr. Fuller if he has anything he wishes to say.

MR. FULLER: I have very little to say, except in answer to one or two of the questions raised. I will say that in the preparation of this report we were guided to a large extent by the replies from a majority of the railroads, and I think it would be better to take the questions that were raised by the members and put them in shape, so that when the letter ballot goes out, if it is so ordered, the matters to which these questions related will be thoroughly understood, and they will be made perfectly clear. As an illustration, in the case of the reduction in the area of the curved heads eighty-nine per cent of the railroads approved of that reduction while some did not. As a general proposition we took the replies as given by the railroads, as the basis of our report, even though they did not in all cases harmonize with the opinion of the committee. However, we will answer all these questions

and send the answers to the Secretary, so that they can be embodied in the ballot.

Mr. Pratt: If the discussion is not closed, I want to say to Mr. Fowler that he was not alone in losing his records. Joe Taylor's "efficiency chart" itself went clear off the screen.

Mr. Fuller: I would ask Mr. Fowler what boiler he had under test, whether it was a wide fire box with straight side sheets, or a narrow fire box with O. G. curves, and sloping head or straight head?

Mr. Fowler: It was a wide fire box boiler, with sloping sides and a slightly sloping crown sheet.

Mr. Fuller: You mean sloping sides, a little to the outside?

Mr. Fowler: Yes, sloping sides, a little to the outside.

Mr. Fuller: Don't you think you would have gotten different readings from one which was absolutely straight, as compared with one which had the O. G. curves?

Mr. Fowler: Of course, no two boilers will act alike.

Mr. Fuller: That is what I thought.

The President: We are about an hour behind our schedule, and we will now take up the next subject, which will be the report of the Committee on Standardization of Tinware. Mr. M. D. Franey, M. M., N. Y. C. R. R., is chairman.

Mr. Franey presented the report, as follows:

REPORT OF COMMITTEE ON STANDARDIZATION OF TINWARE.

To the Members:

The above subject has been referred to your committee with instructions to define standards for all classes of tinware in general use by the mechanical department. We have carefully reviewed the report submitted one year ago and have made some corrections, though no important changes in the details of any of the articles submitted at that time. We have corresponded with a number of the leading railroads, secured blueprints of the tinware they are using in their various departments and have incorporated in our report items that we feel would be of general interest.

During the year 1911 a very complete paper on "Standardization of Tinware" was presented to the Railway Storekeepers' Association. The committee which compiled the report collected the data from practically all

of the leading railroads, giving the dimensions of the various articles of tinware used in their respective departments, this to include articles manufactured from galvanized iron. Your committee, in preparing this report, has received some very valuable suggestions from the Storekeepers' Committee, the manufacturers of tin plate, and some of the manufacturers of tinware.

It is the opinion of the committee that we can not hope to present dimensions that will be adopted by all railroads. Many of the roads now have their standards; for various reasons they do not wish to depart from same. There are railroads, however, that have not adopted a standard, and while the committee has studied principally the method of construction and the material to be used, it has also selected the dimensions that in its judgment will be most suitable for the service for which each article will be used. This is probably as close as we can ever expect to come to a standard on tinware.

As an illustration, it is well known that a tank bucket has to withstand very severe usage. For this reason your committee is recommending a tank bucket with a bottom of very small diameter, designed with a specially formed wire guard fastening the bottom in place. The bottom of the bucket is also depressed so that it can set over a projection without injury. The malleable ears on this bucket have been lowered so that the bucket may be inverted without the ears touching the ground. This form of construction will better withstand the service and the force of any blow to which the tank bucket may be subjected.

Your committee has endeavored to reduce the number of articles used to a minimum, and we find that a number of roads get along with the articles mentioned in this report. We have not included headlights, cab lamps, lanterns or markers, as we find most roads purchase these articles from manufacturers. Very few railroads have detailed drawings of these articles or manufacture them.

Before reviewing the design and construction of the articles to be manufactured, it might be of interest to review some of the commercial terms applied to the tin plates used in construction, which are referred to as "Coke Tin," "Charcoal Tin" and "Terne Plates."

COKE TIN PLATES.

The base of these plates is the best soft steel, made especially for tinplating. The word "Coke" is a trade term, indicating finish. The trade has retained it from the time when high-grade tin plates were made from charcoal iron and lower grades from coke iron; hence plates with lighter coating are called "Coke Tin Plates."

STANDARD WEIGHTS AND GAGES OF TIN PLATES.

Tin plates are generally packed in boxes, and the unit of value and measurement is known as a base box, which is 112 sheets of 14 by 20 in., or 31,360 sq. in. of any size.

No.	Lb.	No.	Lb.
38	55	31	90
37	60	31	95
36	65	30½	100
35	70	30 IC	107
34	75	29	118
33	80	28 IX	135
32	85	28 IXL	128
28 DC	139	25 4X	195
27 2X	155	25 4XL	188
27 2XL	148	24 D2X	210
26 3X	175	23 D3X	240
26 3XL	168	22 D4X	268
26 DX	180		

CHARCOAL-TIN PLATES.

The base metal of these plates is specially prepared with a view to securing a high gloss and a fine working quality. The trade term, "Charcoal," is referred to in the description of "Coke" finish. It is customary to distinguish the amount of coating the degree of finish by letters "1-A," "2-A," etc., up to and including "5-A." "1-A" grade has the least amount of coating, and each "A" signifies an additional quantity.

One of the leading manufacturers gives the following tabulation for various brands; showing the approximate weight of coating on both sides of the sheet per base box of 112 sheets, 14 by 20 in. For 112 sheets, 20 by 28 in., the weight of coating would be double that shown in the table.

	Lb.
1-A charcoals	3
2-A charcoals	3½
3-A charcoals	4
4-A charcoals	5
5-A charcoals	6
Premier	7

They recommend the Premier brand as suitable for all high-class work, such as nickel-plating.

TERNE PLATES.

Terne plate, which is generally known as roofing tin, is a product made by coating steel or iron sheets with a mixture consisting of approximately 25 per cent tin and 75 per cent lead. These plates are made from copper-bearing, open-hearth steel. The manufacturers claim that steel of this character amalgamates with the tin and lead mixture in such a manner as to produce a better plate than is possible with ordinary steel, and as a consequence resists corrosion to a remarkable degree. It is also as soft as the best charcoal iron.

Practically all of the roofing tin made prior to 1890 was produced by what is known as the "Palm Oil" process, but it is claimed that plates made in the nineties by the acid process are still in use and giving good service. The manufacturers claim plates finished by the acid process are fully as good as those finished by the "Palm Oil" process.

It is important that the mixture covers the iron and adheres to every point; otherwise there is liable to be what is known to the trade as "pin-holes," which are injurious and permit corrosion to start. Terne plates, like the other grades, are packed in boxes which show the style of finish, the grade of plate and the amount of coating.

The process of manufacturing does not produce all perfect sheets, which are designated by the mill as "prime" plates. A small percentage of the manufactured plates contain pinholes or other defects, and are called "wasters." When prime plates only are desired, the mill charges a premium for such distinction. This extra cost is waived when the wasters are taken in connection with the primes. Some manufacturers do this by packing the primes and wasters separately, in which event no premium is charged for the primes and a reduction is allowed on the wasters. A second method: The primes and wasters are packed together just as produced and the mills call these unassorted. An allowance is made for taking the wasters in this manner.

CASE OR PACKAGE MARKS.

The cases should show the brand and thickness; erasure of any stencil mark placed on the case by the manufacturer should be promptly noted as requiring careful inspection of contents. Prime plates are known to be in the case by the original condition of the case and by the absence of the waster mark; some manufacturers use a large capital letter "W" to indicate wasters, others use capital letters "US" to designate unassorted.

TINWARE.

In the prints submitted we have endeavored to cover every detail, making parts interchangeable where this is practical. It will be noted the joints are double-seamed where such seams are desired, and the detail of the seam is carefully outlined. Figure O gives the description and name of the joints used in the construction of this tinware. While the material is specified, it should be remembered that custom has handed down the practice of specifying and using IX tin. It is the opinion of the committee that cheaper grades of tin could be used in many cases, and this is left to the judgment of the members, after reading the foregoing description on the manufacture of tin plates.

Through the courtesy of the Eagle Glass Mfg. Company the committee has examined samples of oil cans made from sheet steel, the joints of which have been brazed. We are not in a position to say how this compares in cost with standard tinware, and in our correspondence we have

been unable to get sufficient data on this subject to incorporate it in our report.

Through the courtesy of the Johnson Mfg. Company the committee has been enabled to present for the inspection of the members samples of tinware recommended These have been furnished gratis. Many of you have seen the exhibit in the adjoining building in the booth of the American Car & Foundry Company. We would respectfully request the members who have not looked at this tinware to examine it and give us their criticism. Mr. Isaac T. Johnson will be found at the booth, and the committee hopes to profit by the criticisms made by our members. Such of those criticisms as appeal to the committee will be incorporated in our report before finally submitting same.

With the permission of the members I will refer briefly to the changes we have made after reviewing the above criticisms. This will be made in considering each article.

Fig. 1 shows an engineers' torch that is used on one of our railroads. They claim to be getting very good results from same. The special feature of this torch is a cap which screws over the top and prevents oil wasting out into the seat box when the torch is not in use. This feature makes it very popular with the enginemen. Each torch is numbered and recorded. When the torch is given to the engineer it becomes his individual property and is charged out to him the same as any other company property. On account of the special finish of the torch the engineers take a personal pride in retaining them. This road in question has used these torches for several years, and the original torches are still in the possession of the engineers; very few of them are lost. While this torch is not tinware, it is used as a substitute for tinware. Its attractiveness makes it an economical proposition because few are used as compared with the ordinary tin torch, and a saving in thereby effected.

Fig. 2 shows a very satisfactory form of torch, used on some roads for enginemen and shopmen.

Fig. 3 is a squirt oil can made of tin.

Fig. 4 is a pressed-steel squirt oil can, which can be purchased in the market, and is merely shown as an alternative where such a can is desired.

Fig. 5 shows two forms of long-spout engine oil can in quite general use. It is claimed that the amount of oil saved by the use of these cans will pay for the cost of construction.

Fig. 6 is a one-pint signal oil can. This is furnished on the engine, principally in winter weather, to carry a small amount of oil for emergency use. It is made small and compact to withstand rough usage and to save material. This can may also be used as a lamp filler for train service, station service, or where such a filler is required.

Fig. 7 is a three-pint valve oil can with an internal strainer made of perforated tin. The opening in the top is made small to require the heat-

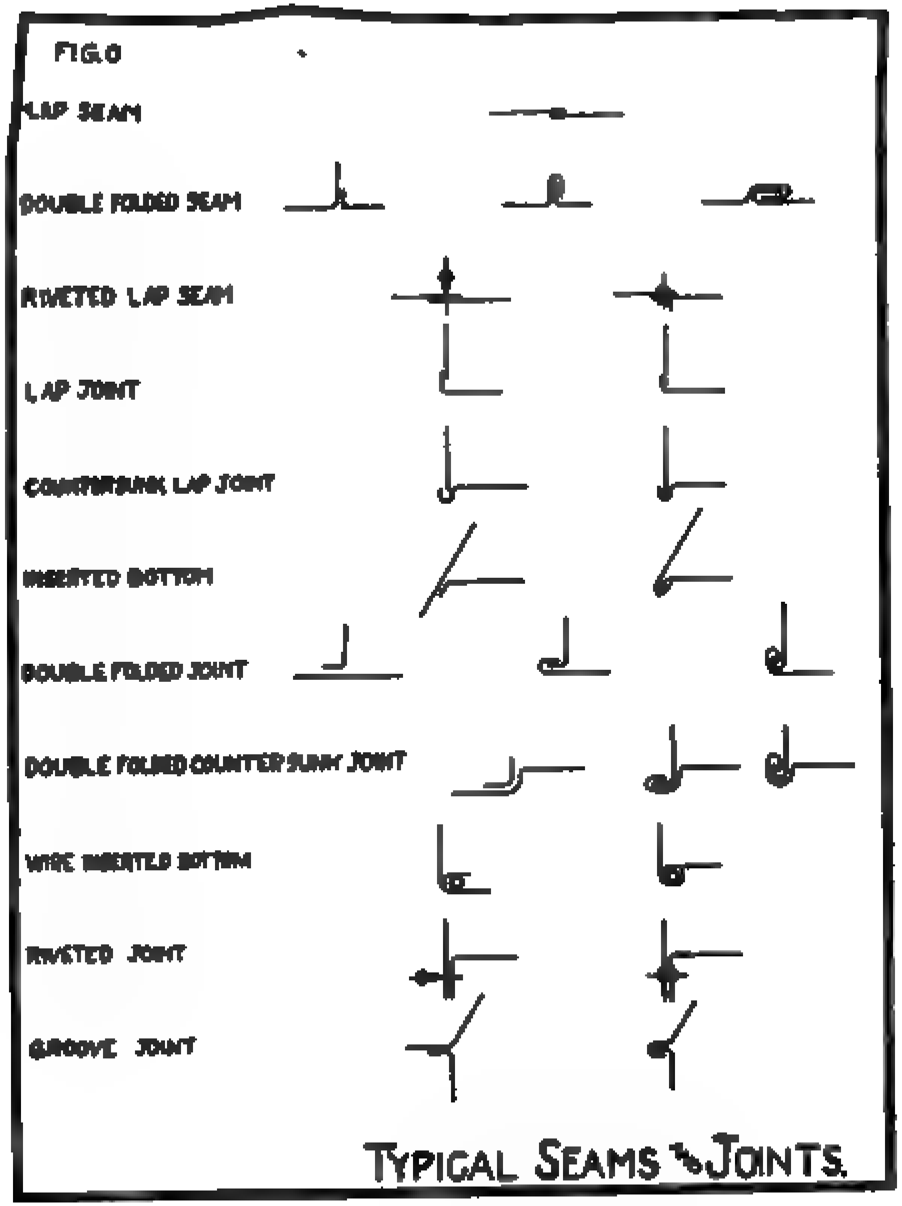


FIG. 0
LAP SEAM
DOUBLE FOLDED SEAM
RIVETED LAP SEAM
LAP JOINT
COUNTERSUNK LAP JOINT
INSERTED BOTTOM
DOUBLE FOLDED JOINT
DOUBLE FOLDED COUNTERSUNK JOINT
WIRE INSERTED BOTTOM
RIVETED JOINT
GROOVE JOINT
TYPICAL SEAMS & JOINTS.

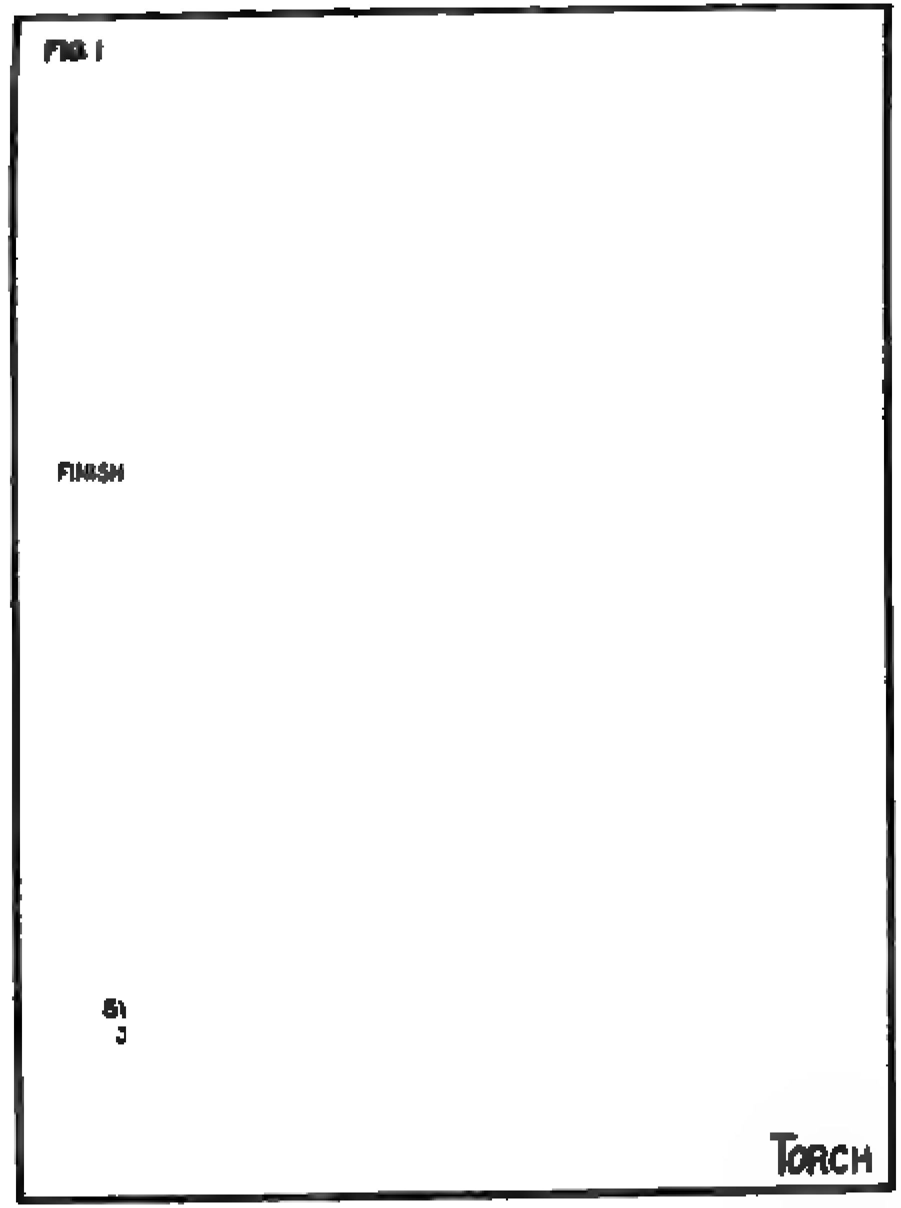


FIG. I
FINISH
TORCH

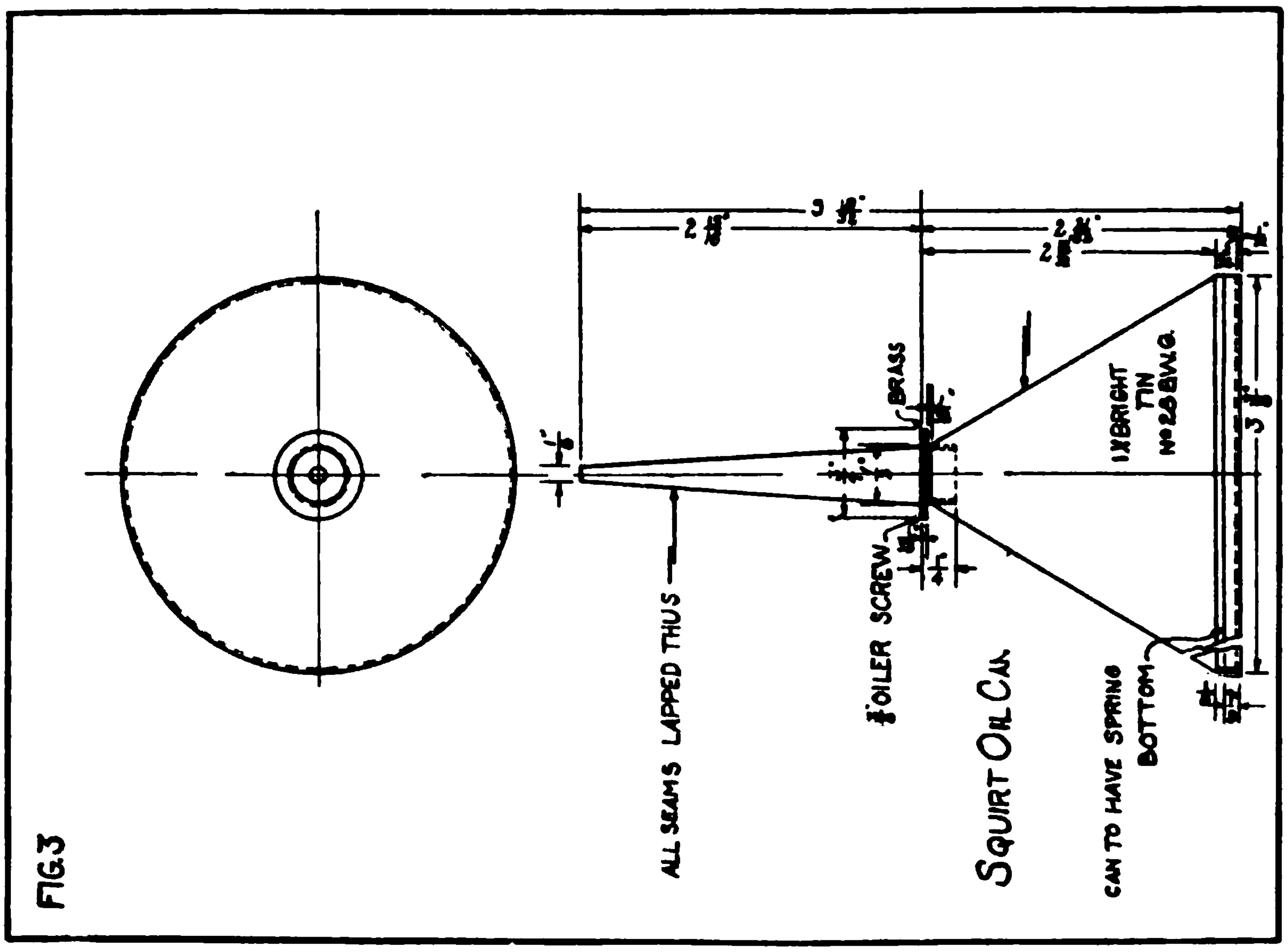


FIG.3
ALL SEAMS LAPPED THUS
BRASS
1/8 OILER SCREW
SQUIRT OIL CAN
1X BRIGHT TIN No 28 B.W.G.
CAN TO HAVE SPRING BOTTOM

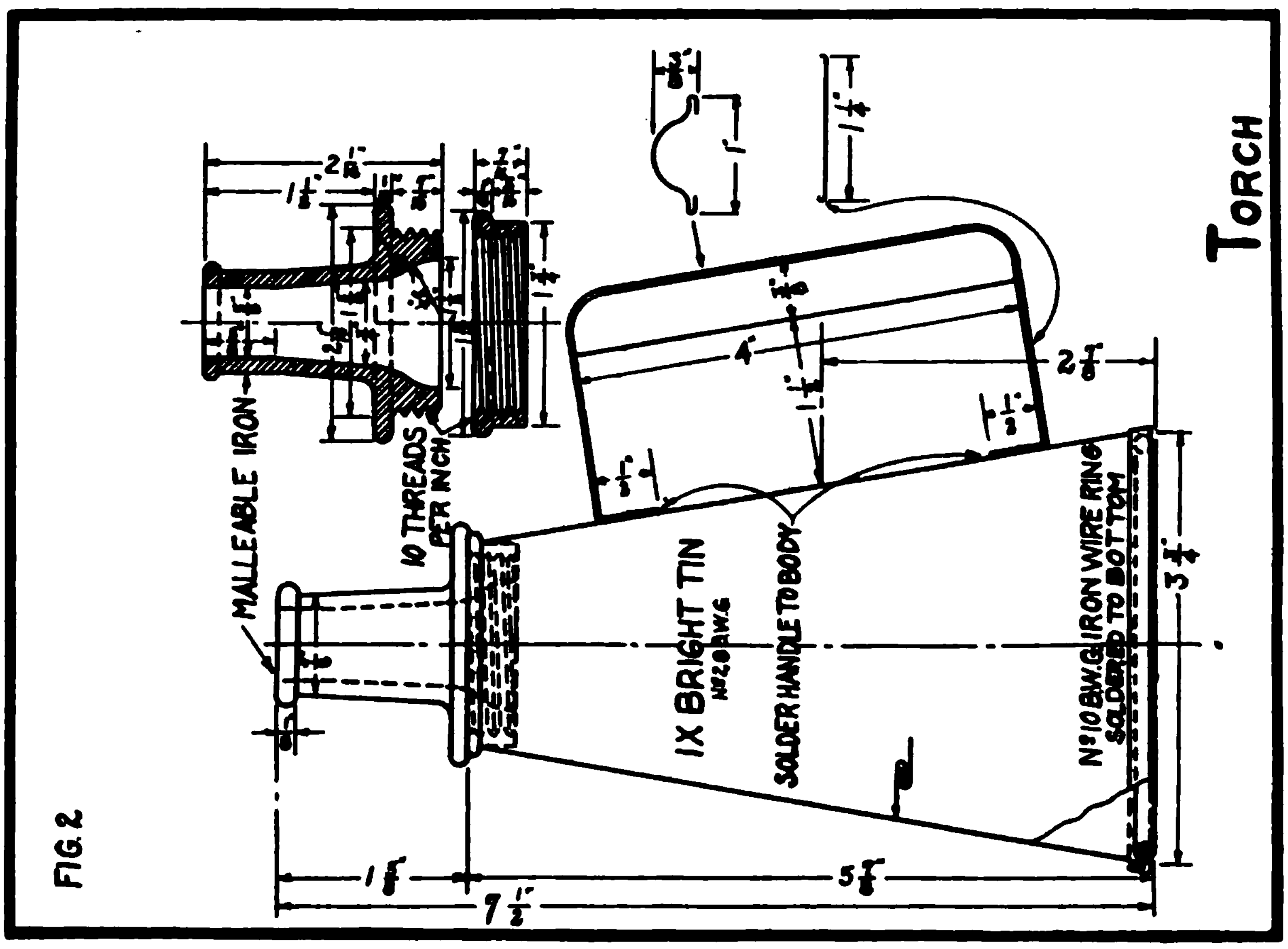
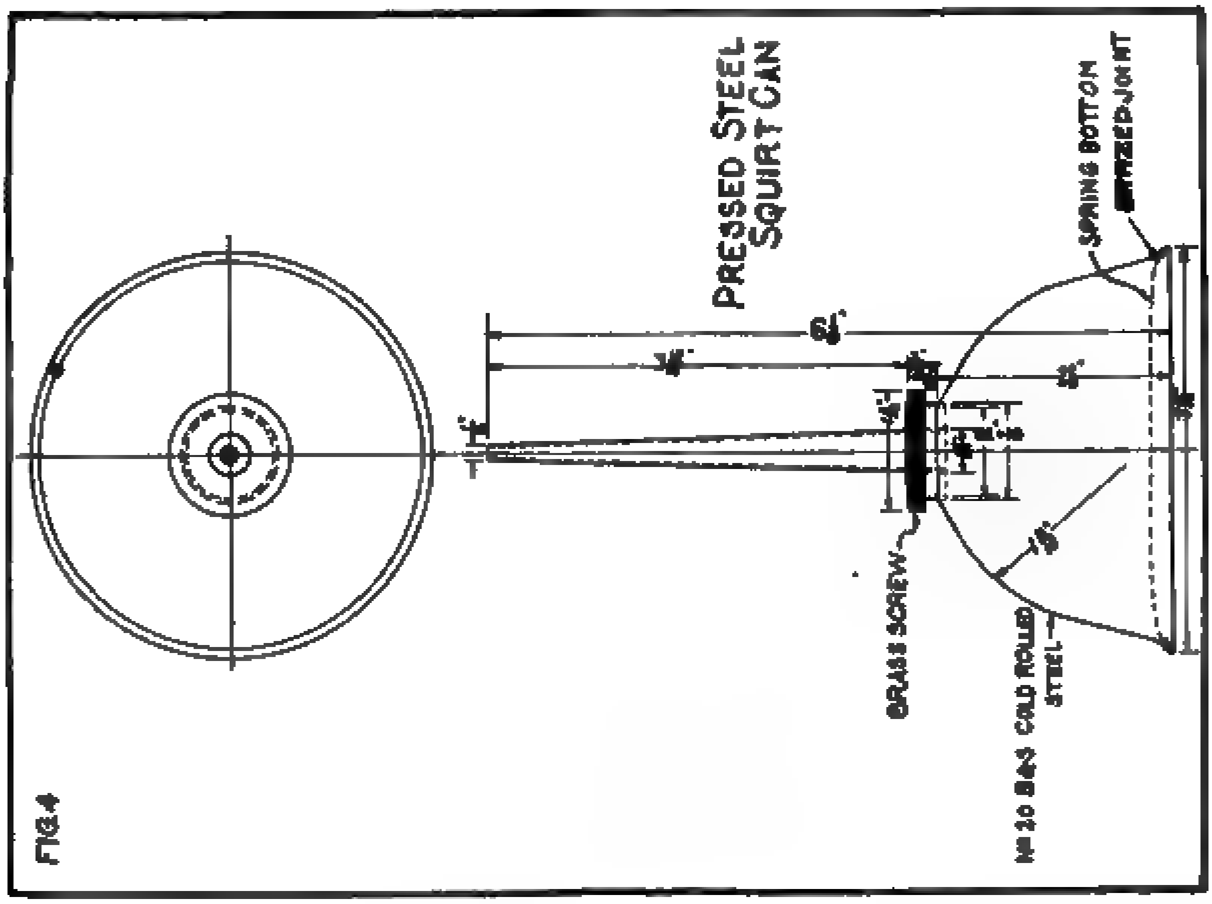


FIG.2
MALLEABLE IRON
10 THREADS PER INCH
1X BRIGHT TIN No 28 B.W.G.
SOLDER HANDLE TO BODY
No 10 B.W.G. IRON WIRE RING SOLDERED TO BOTTOM
TORCH


PRESSED STEEL SQUIRT CAN
SPRING BOTTOM
BRAZED JOINT
BRASS SCREW
Nº 20 B&S COLD ROLLED STEEL
FIG.4

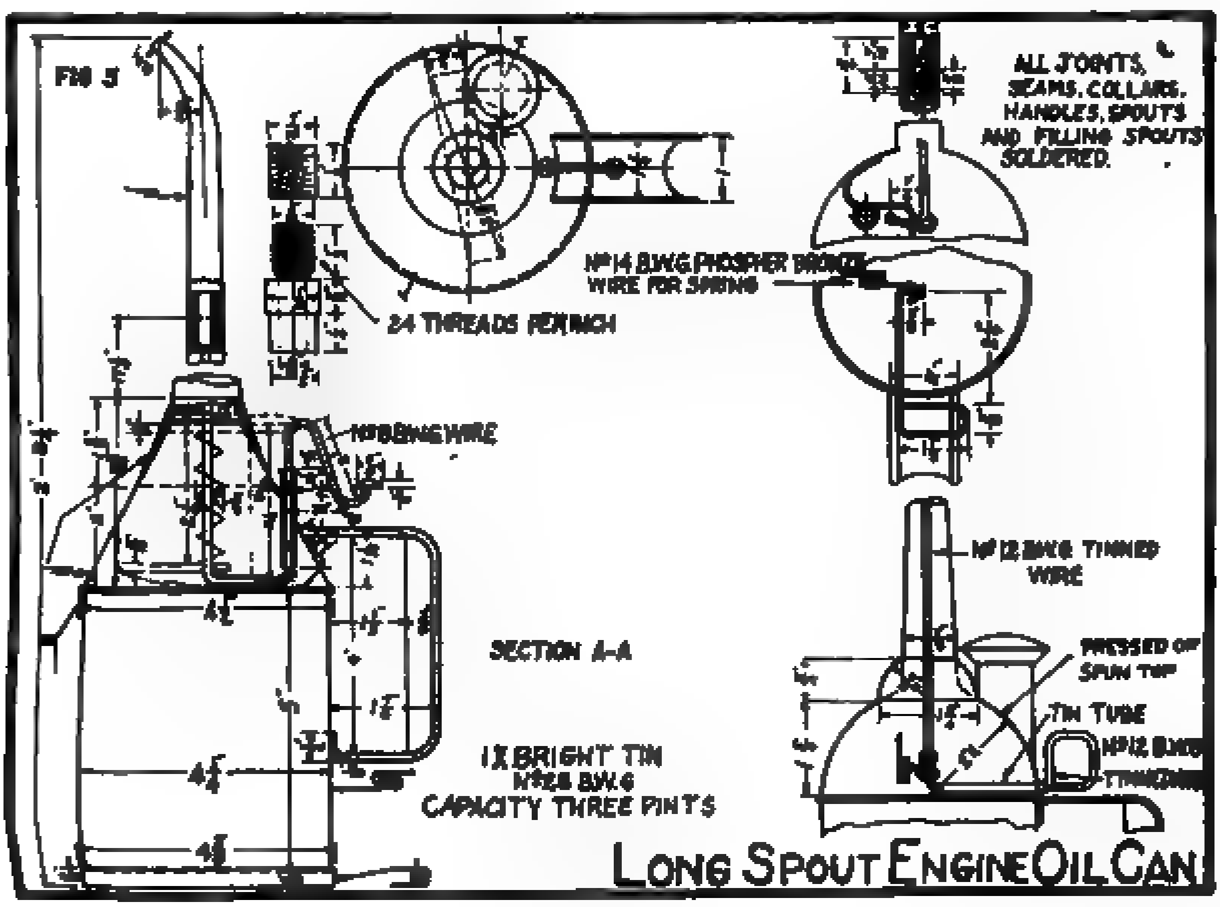
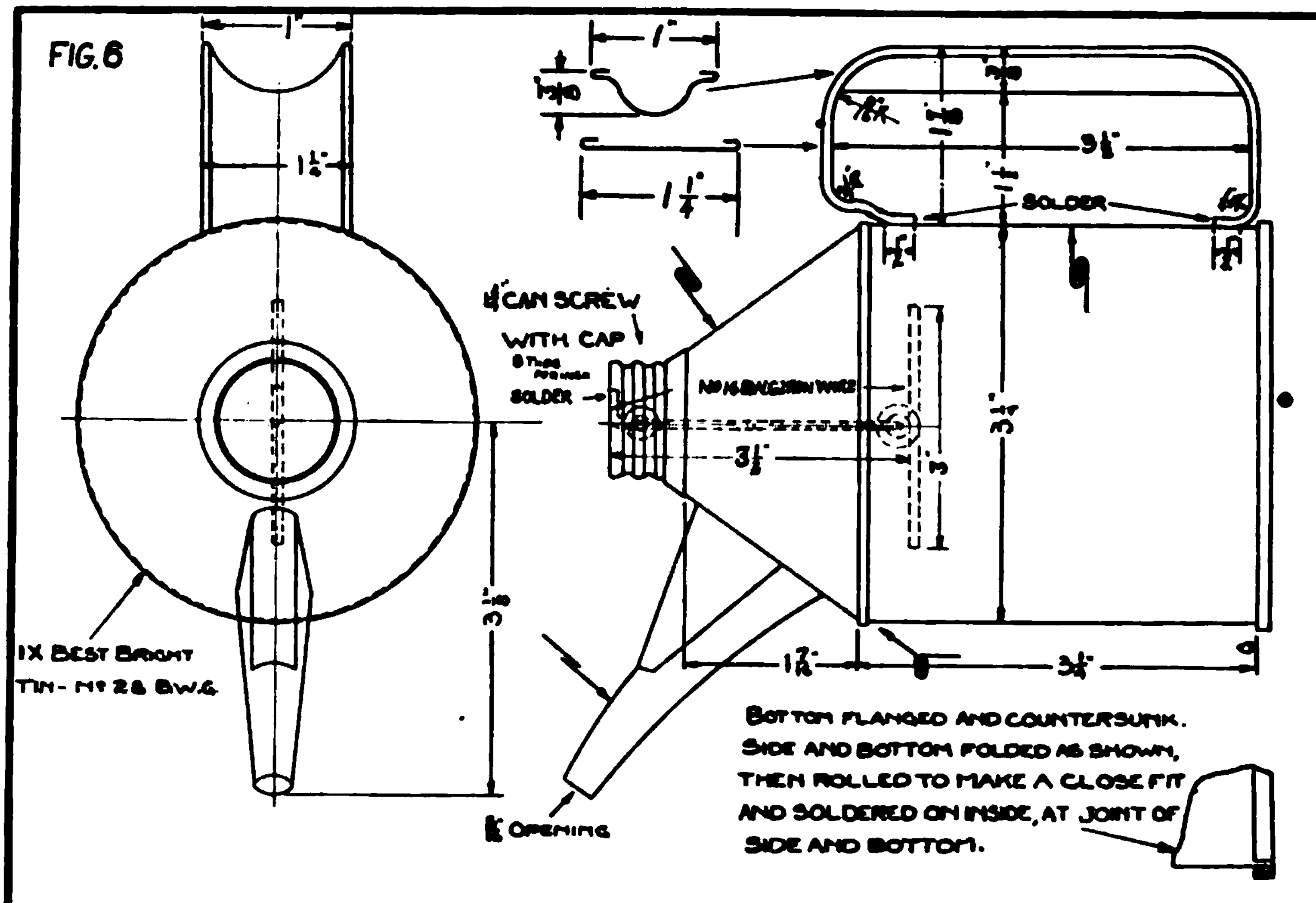


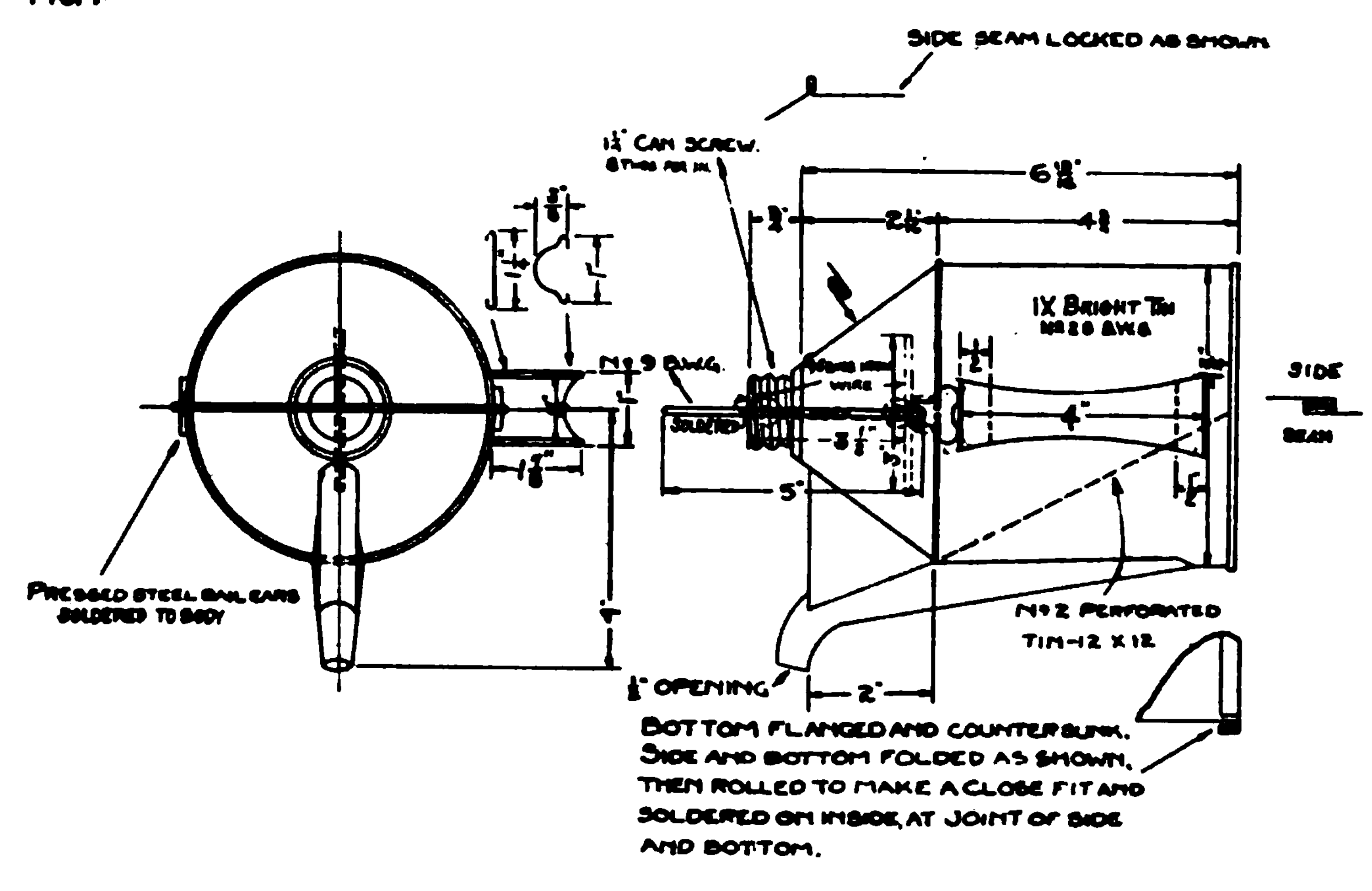
FIG 5
ALL JOINTS, SEAMS, COLLARS, HANDLES, SPOUTS AND FILLING SPOUTS SOLDERED.
Nº14 B.W.G. PHOSPHER BRONZE WIRE FOR SPRING
24 THREADS PER INCH
Nº12 B.W.G. TINNED WIRE
SECTION A-A
PRESSED OR SPUN TOP
TIN TUBE
IX BRIGHT TIN
Nº28 B.W.G.
CAPACITY THREE PINTS
LONG SPOUT ENGINE OIL CAN

FIG. 6



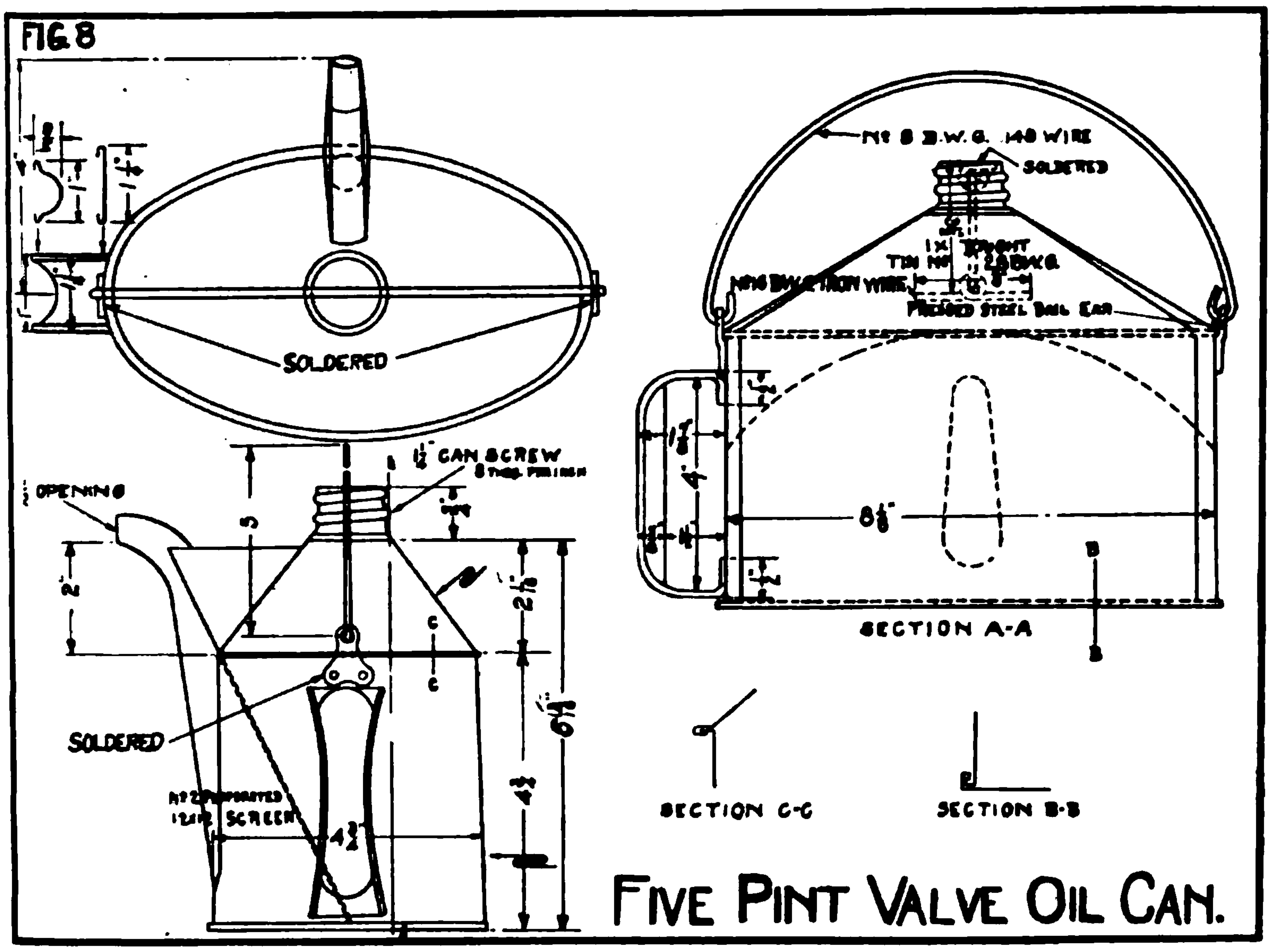
LAMP FILLER AND ONE PINT SIGNAL OIL CAN

FIG. 7



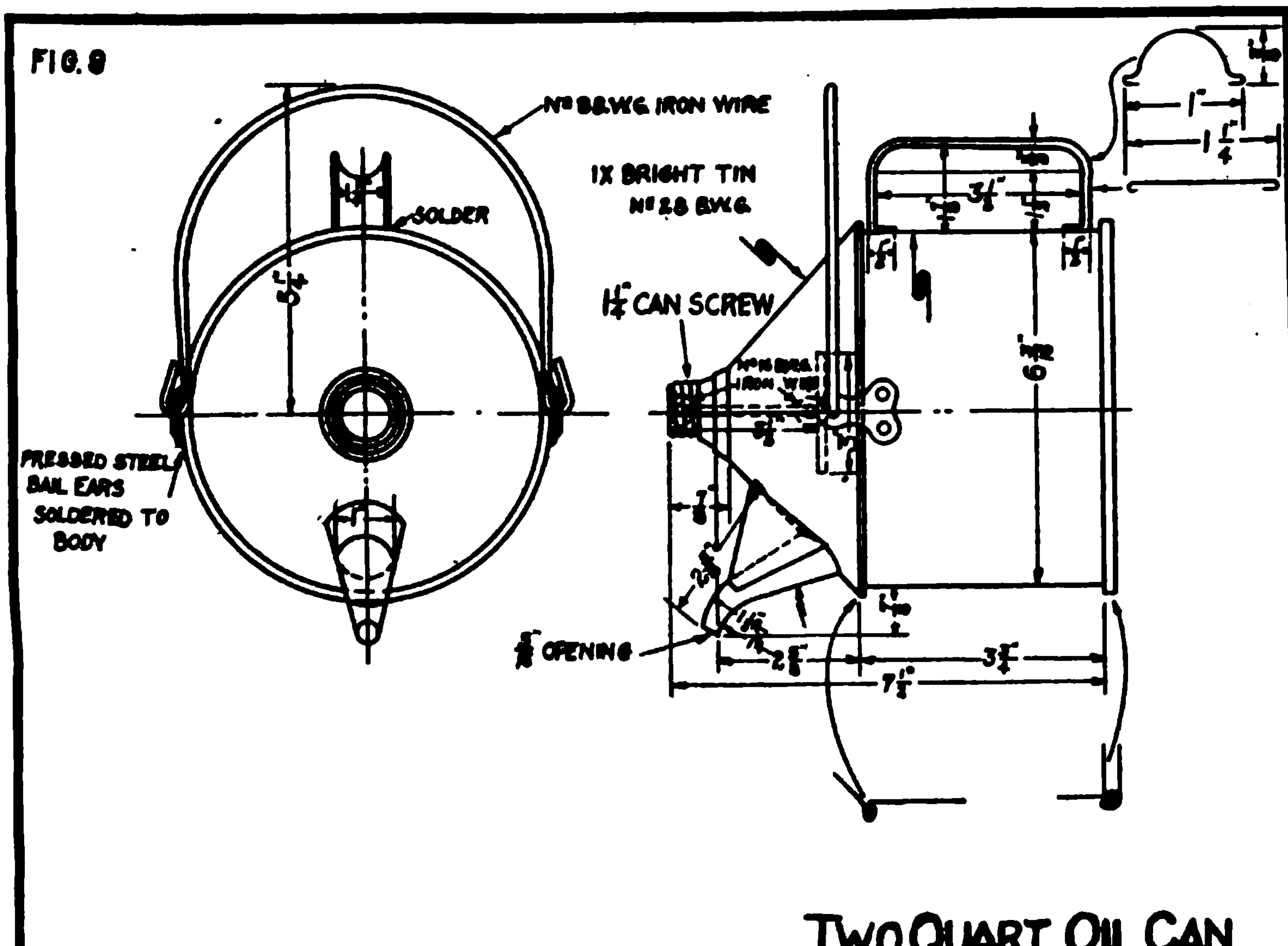
THREE PINT VALVE OIL CAN.

FIG. 8



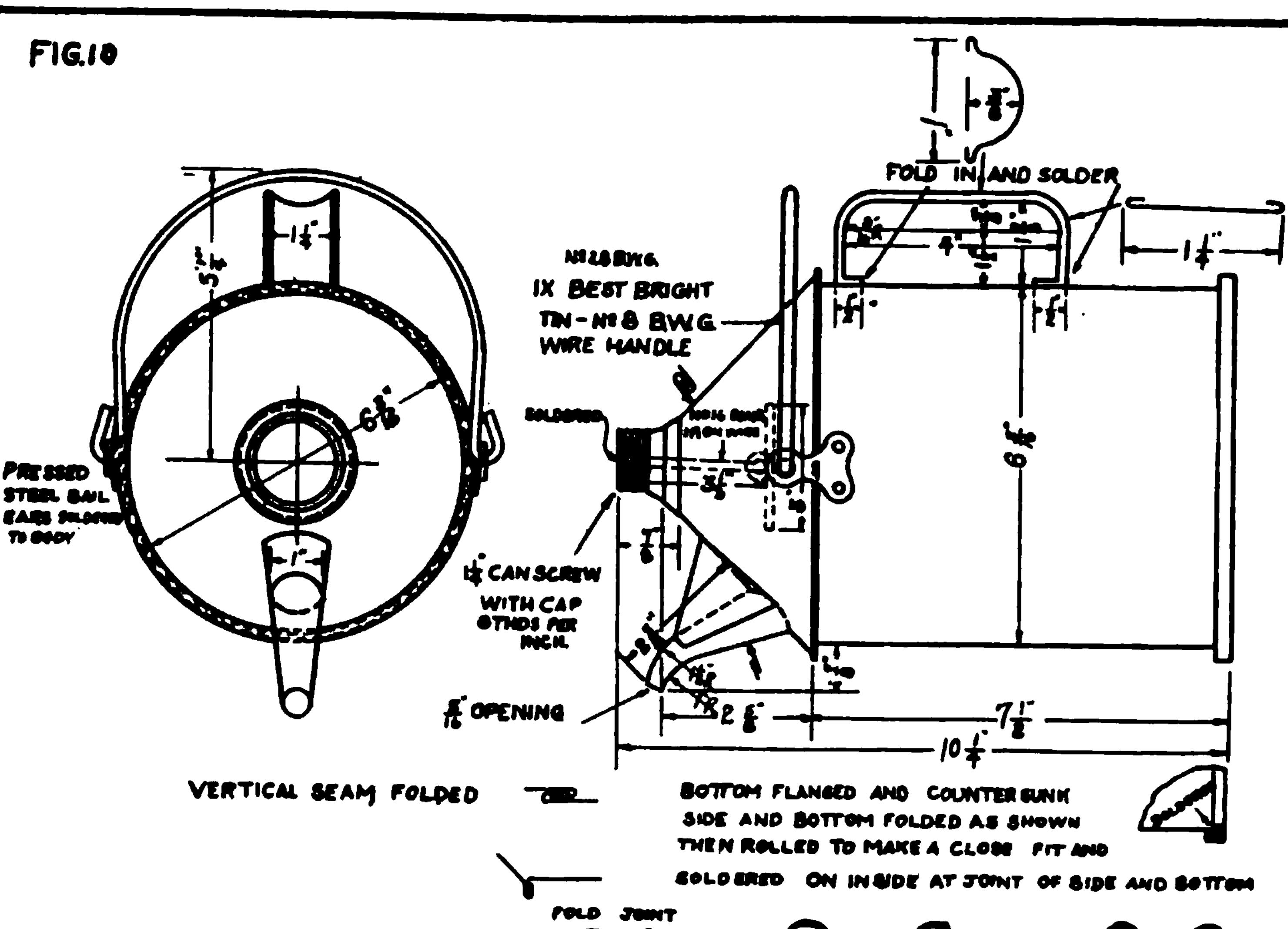
FIVE PINT VALVE OIL CAN.

FIG. 9



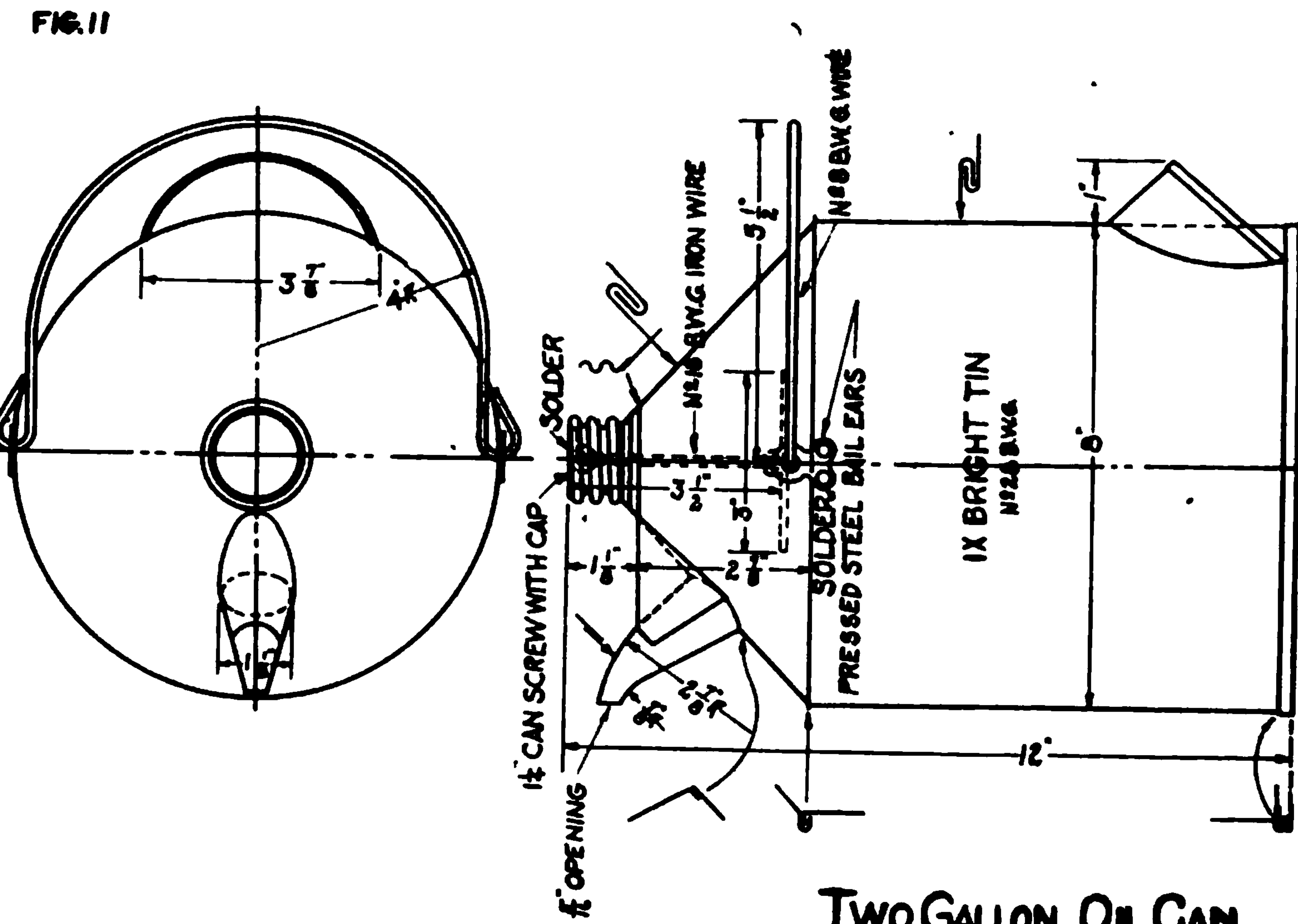
TWO QUART OIL CAN

FIG. 10



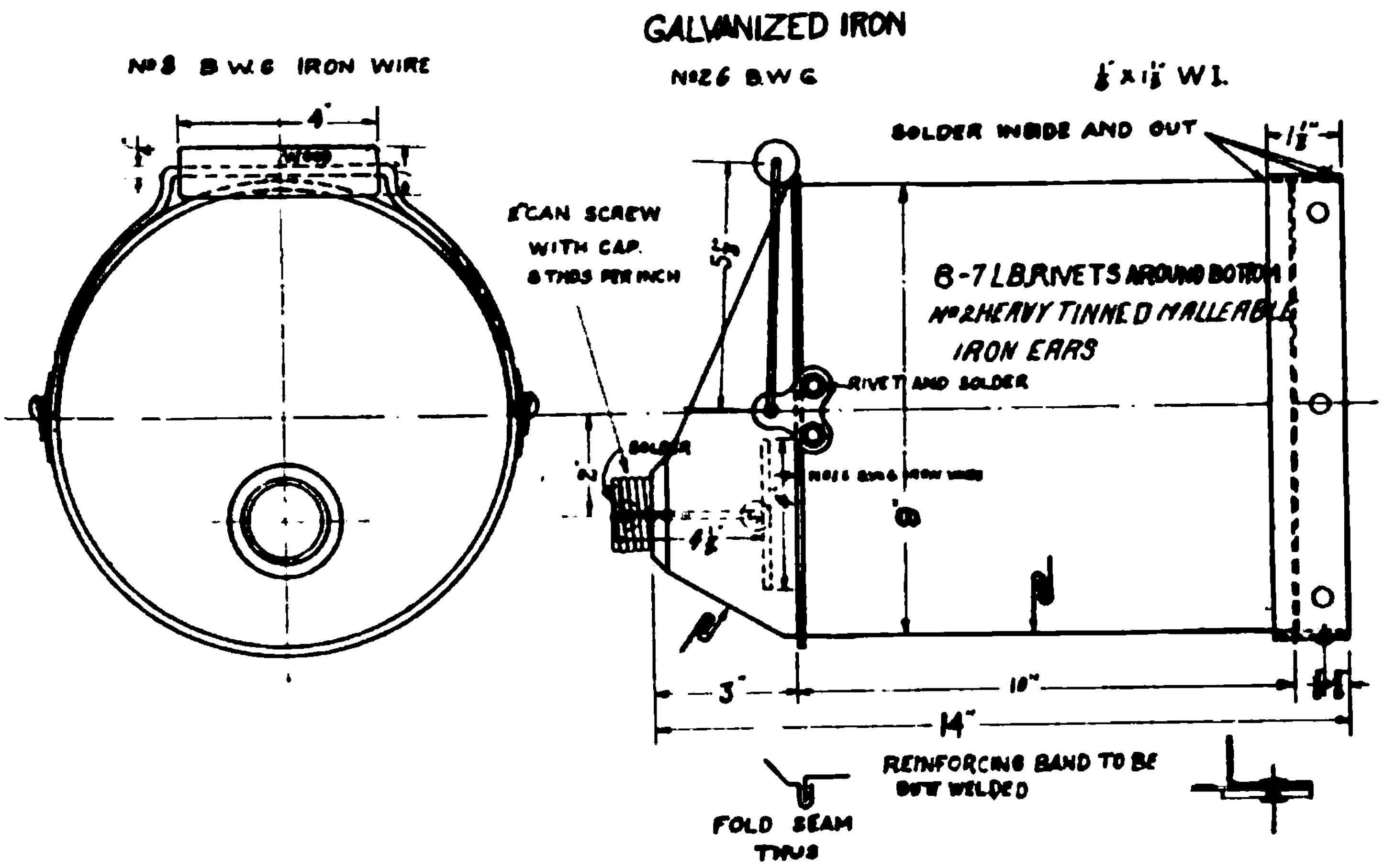
ONE GALLON OIL CAN

FIG. 11



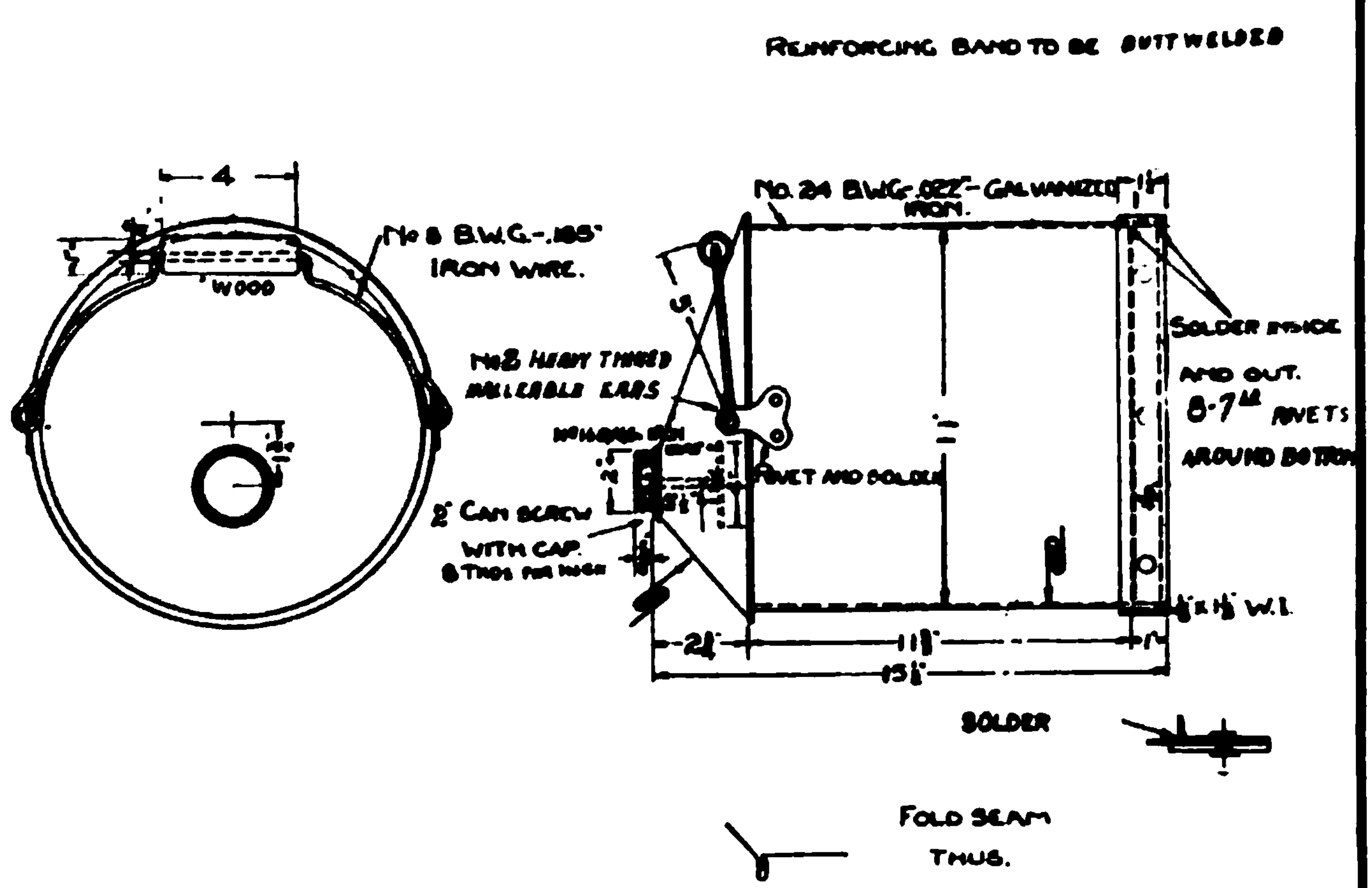
TWO GALLON OIL CAN

FIG.12

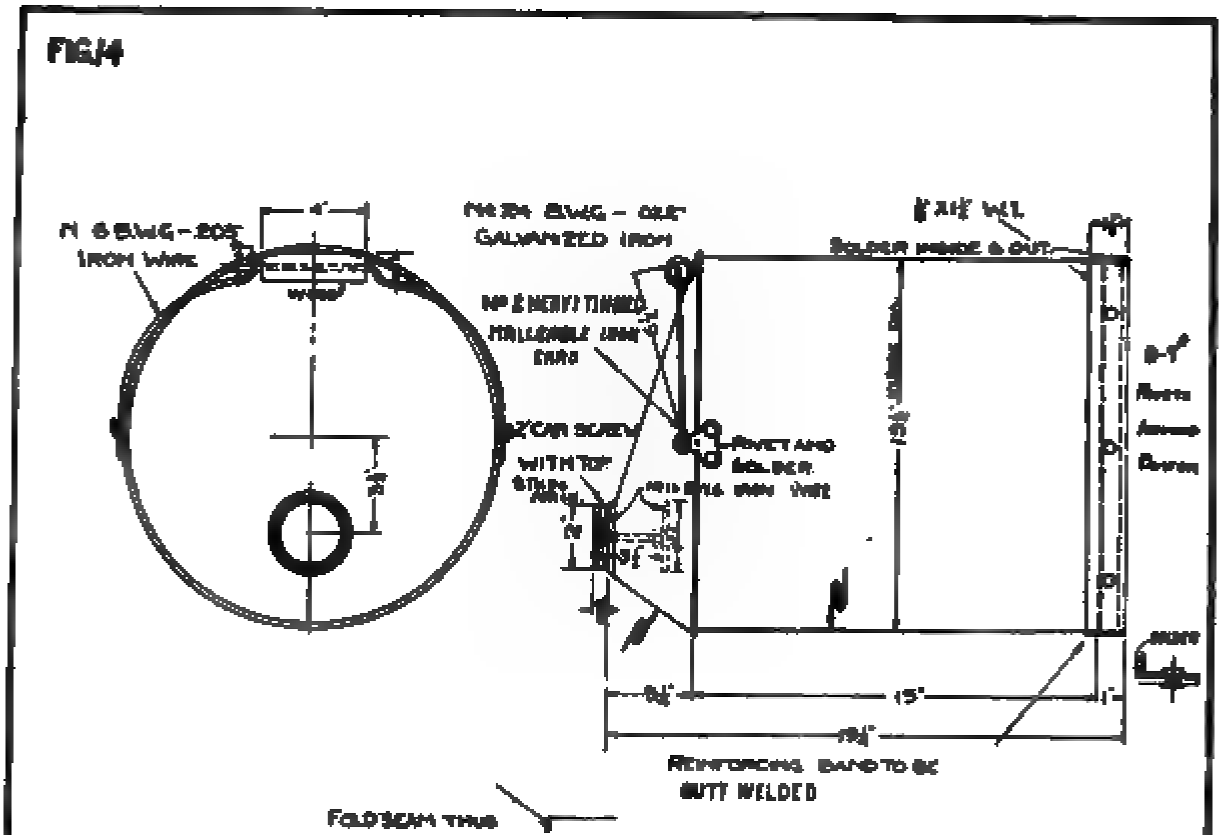


THREE GALLON OIL CAN

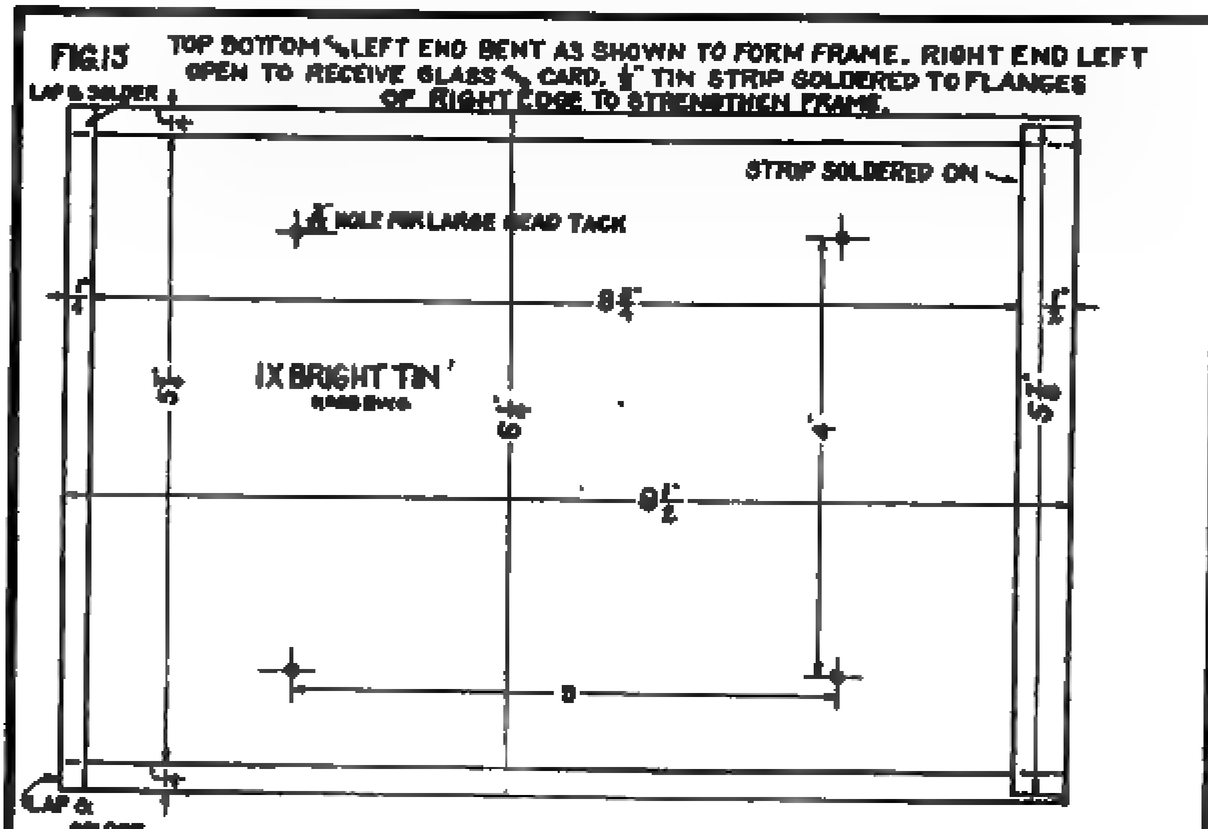
FIG.13



FIVE GALLON OIL CAN.

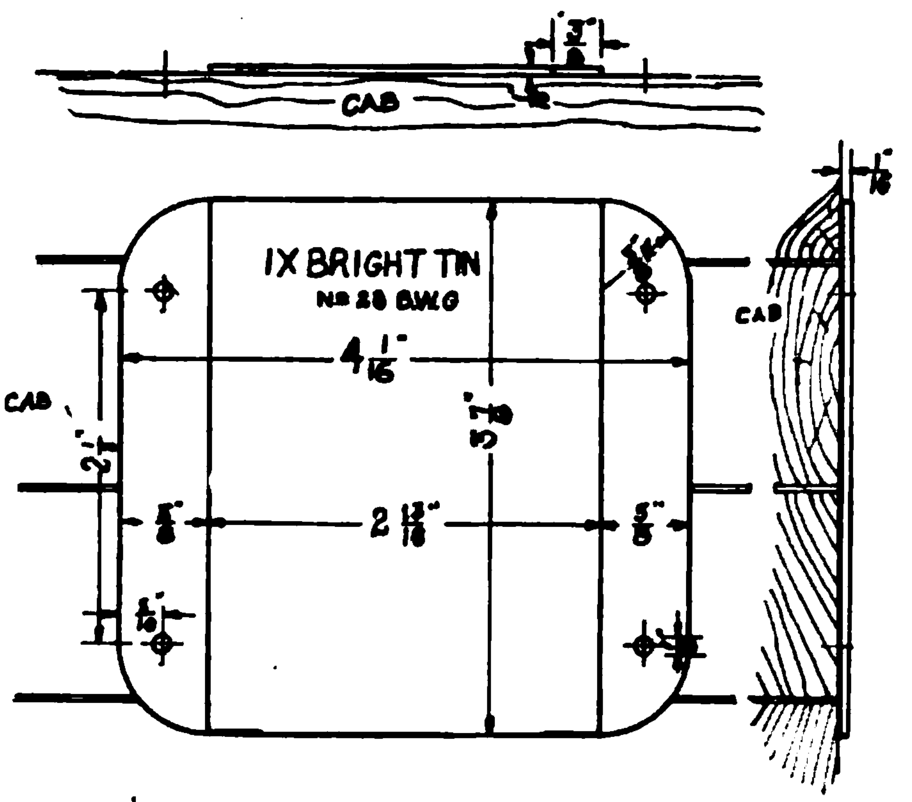


TEN GALLON OIL CAN.



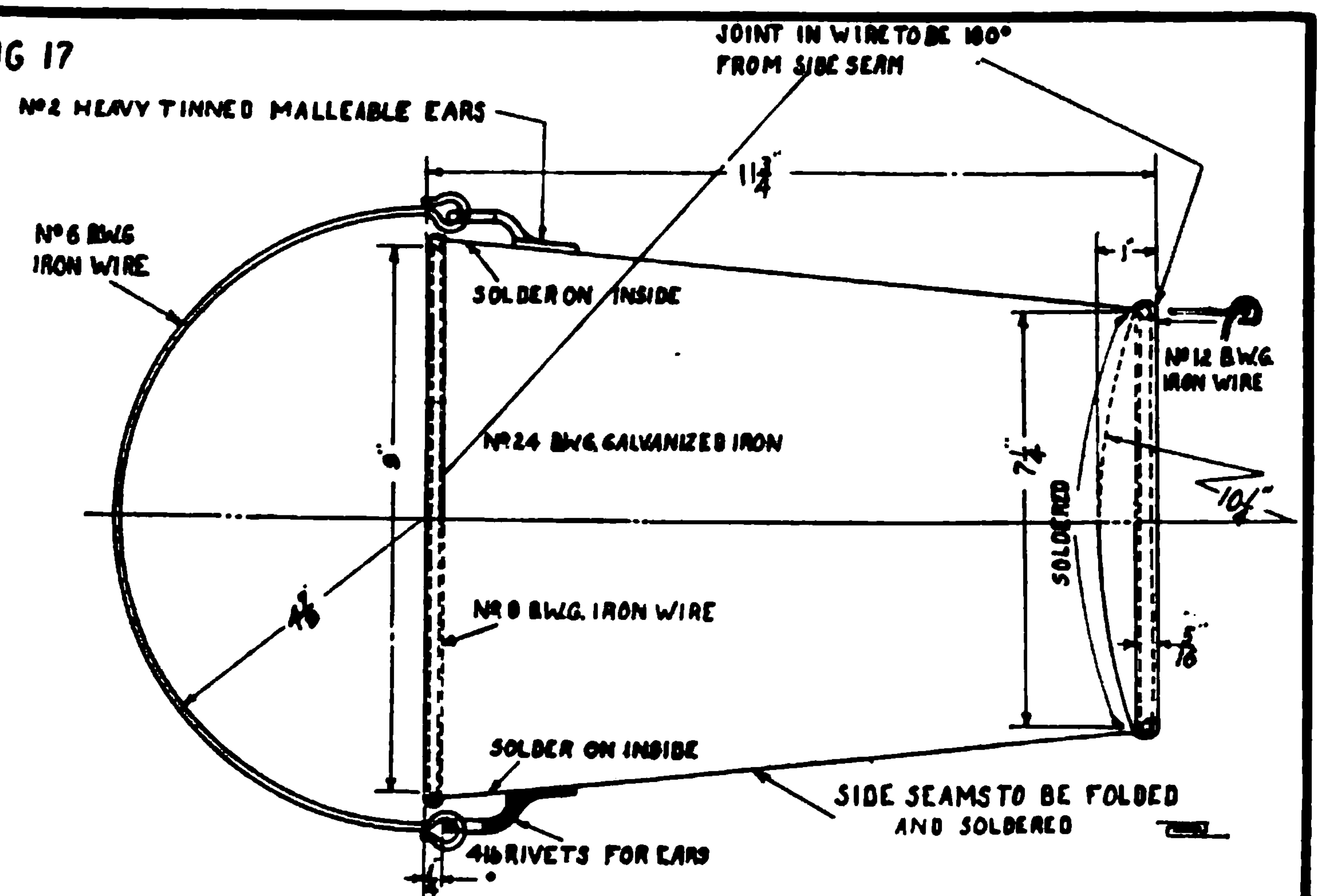
BOILER INSPECTION CARD CASE

FIG.16

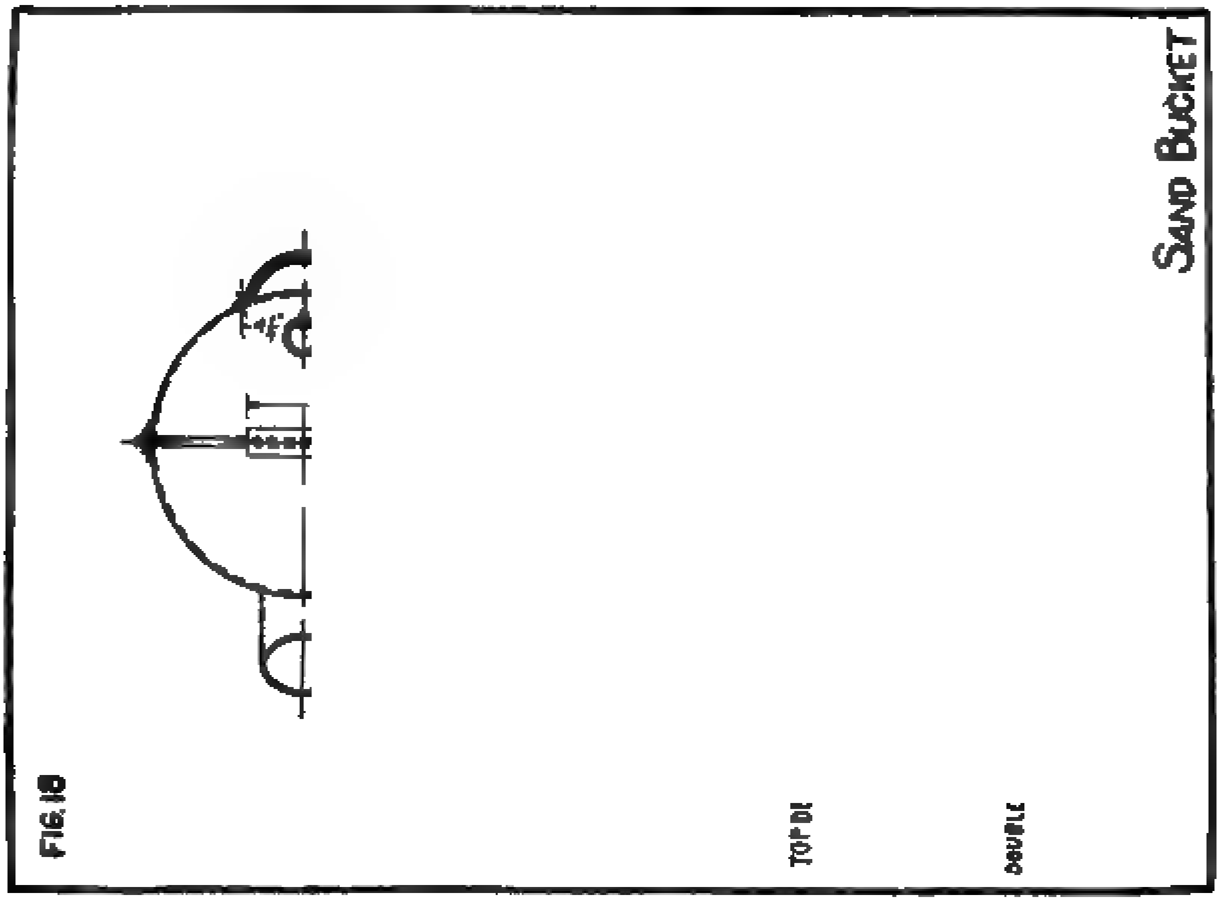


WASH-OUT CARD CASE

FIG 17



TANK BUCKET


SAND BUCKET
FIG. 18
TOP DI
DOUBLE

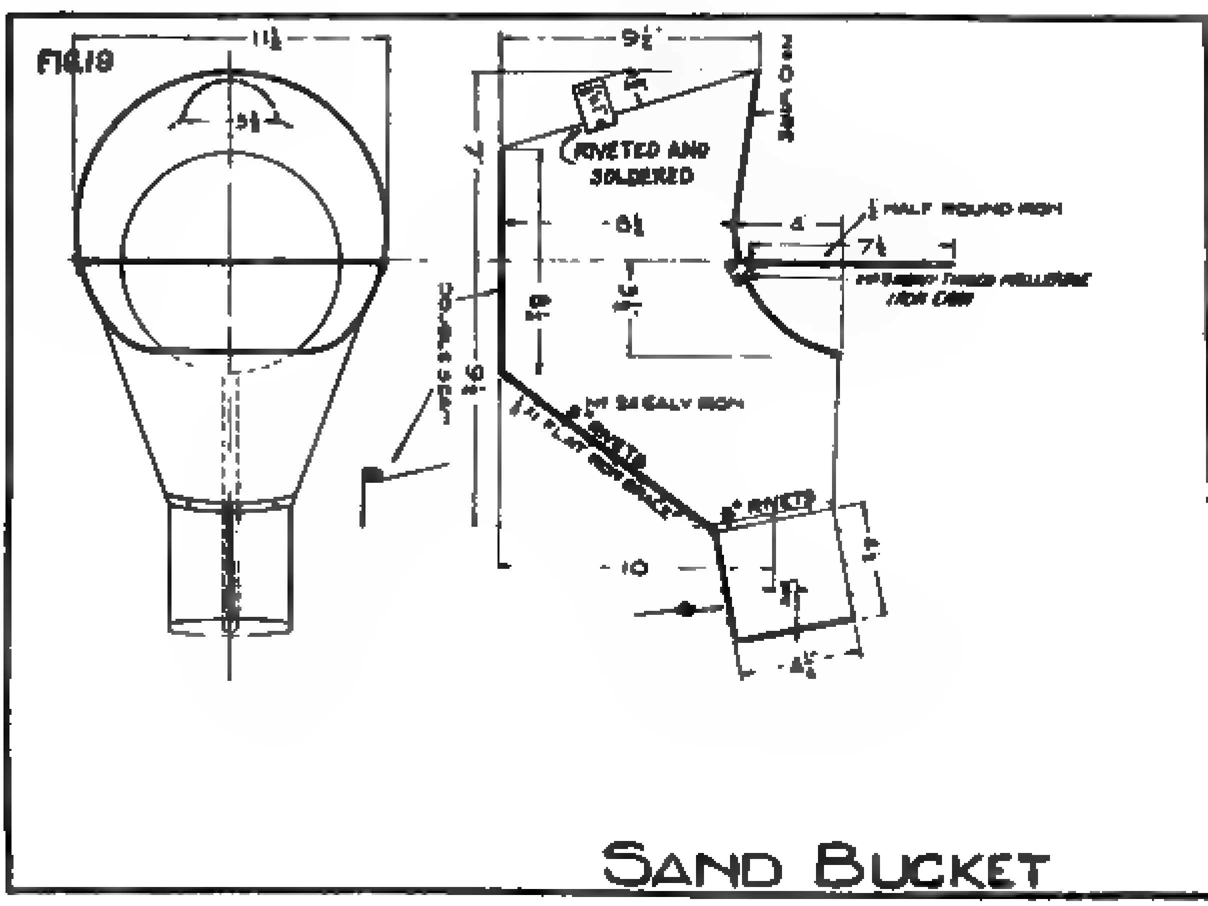


FIG. 19
11½
5½
9½
7
RIVETED AND
SOLDERED
8½
4
½ HALF ROUND IRON
7½
10
4½
SAND BUCKET

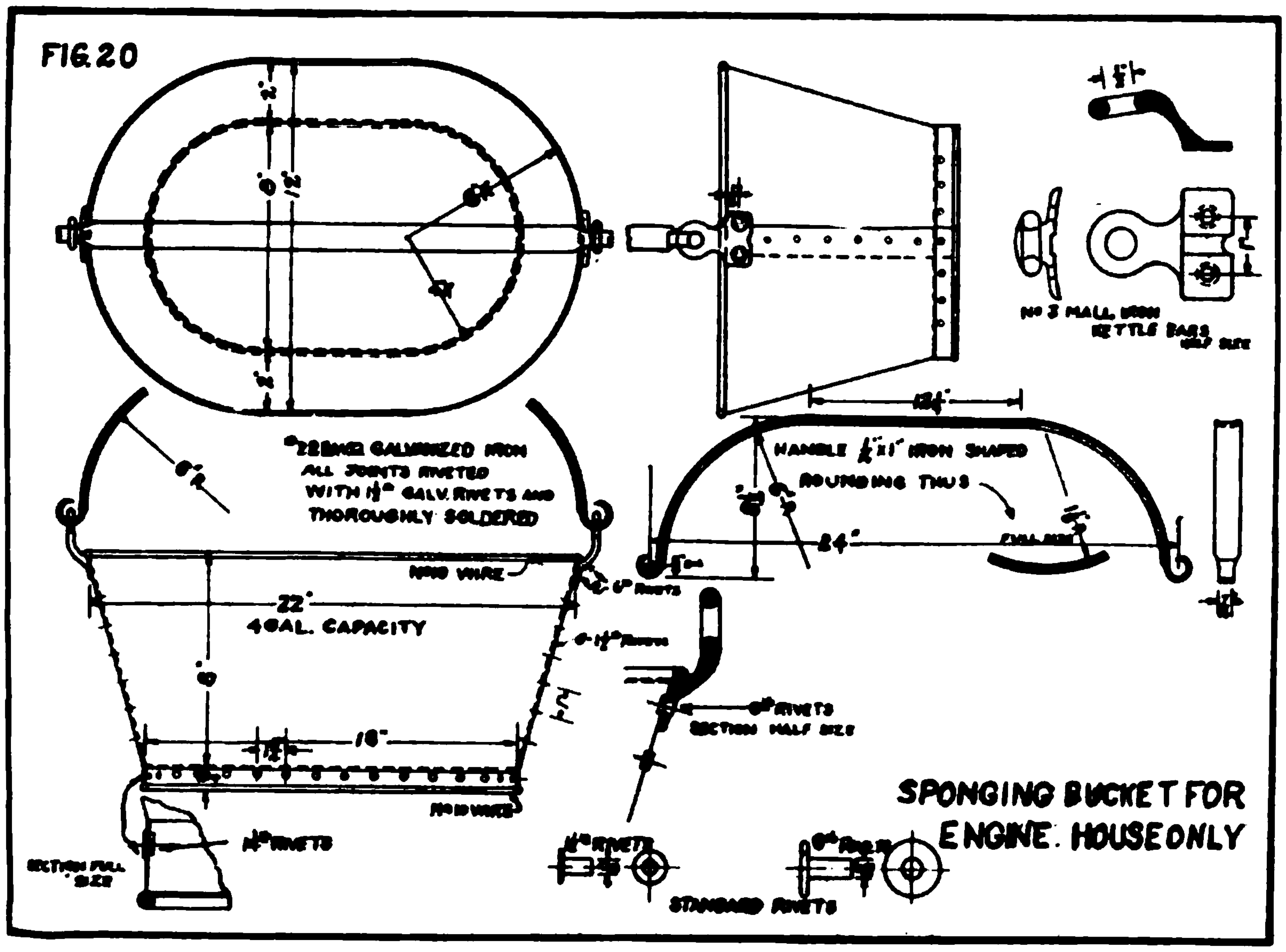


FIG. 20
22"
4 GAL. CAPACITY
16"
SPONGING BUCKET FOR ENGINE HOUSE ONLY
STANDARD RIVETS

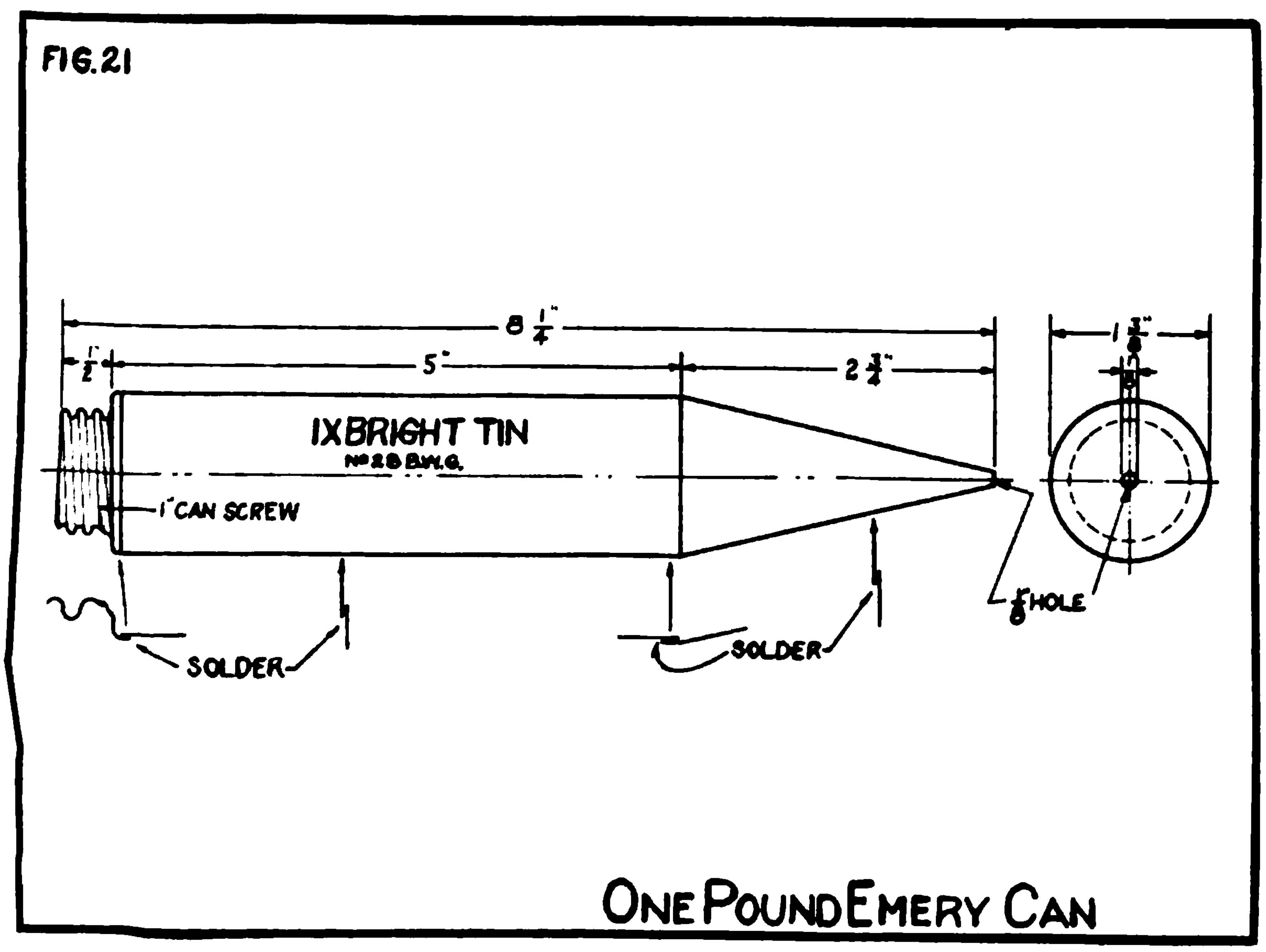


FIG. 21
8 1/4"
5"
2 3/4"
1 3/8"
IXBRIGHT TIN
1" CAN SCREW
SOLDER
SOLDER
1/8 HOLE
ONE POUND EMERY CAN

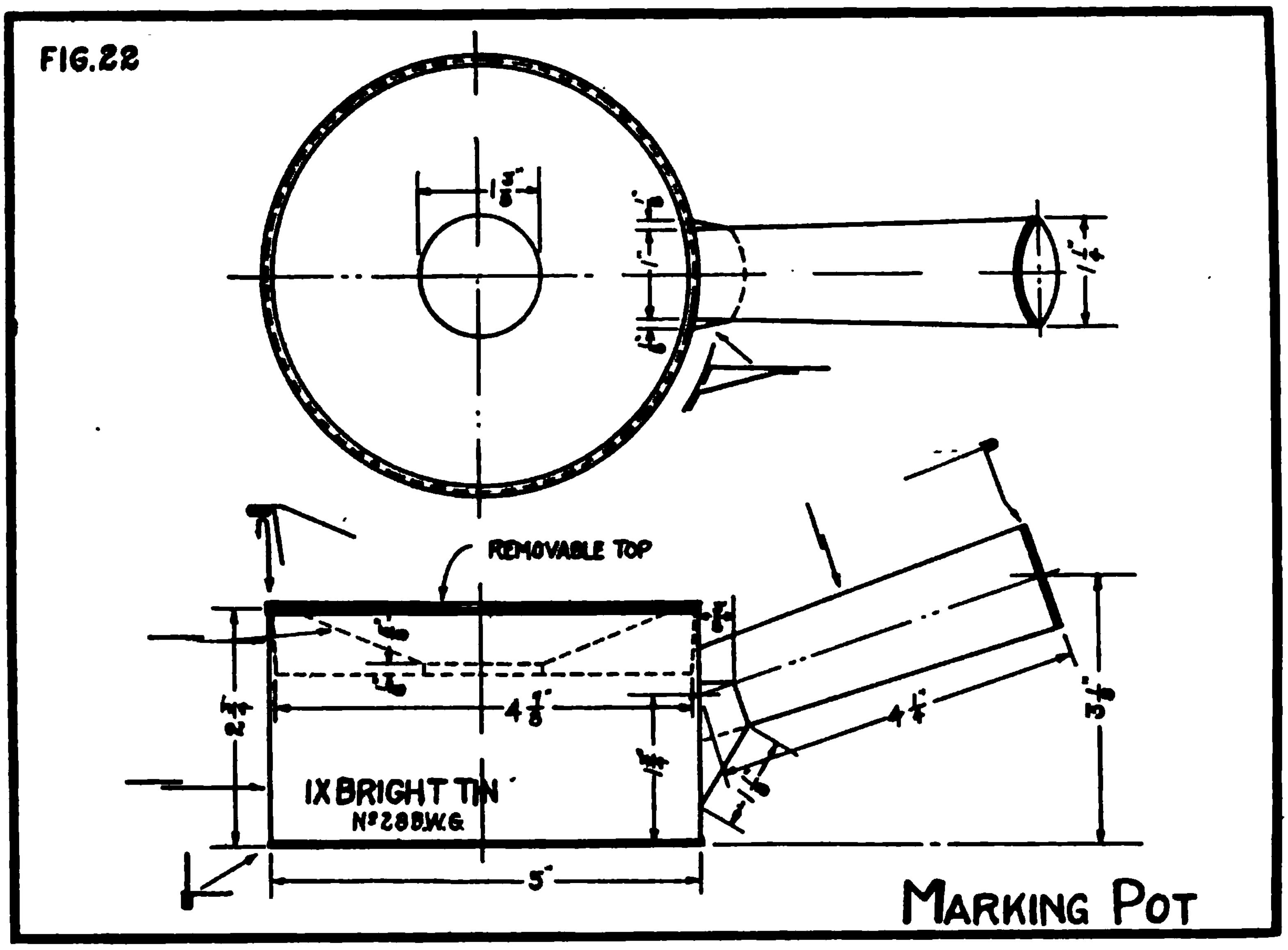


FIG.22
REMOVABLE TOP
IX BRIGHT TIN
Nº 28 B.W.G.
MARKING POT

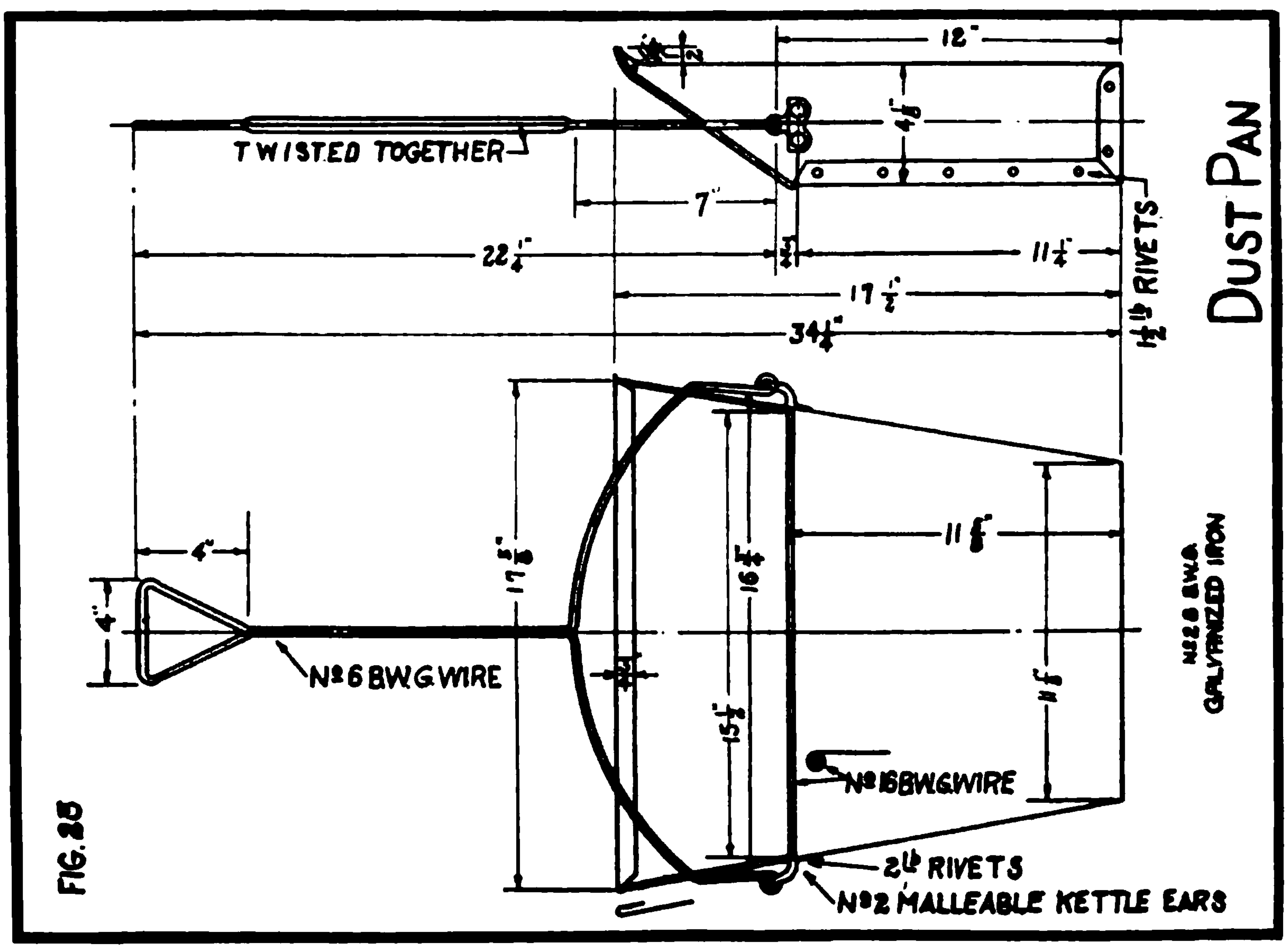


FIG.23
DUST PAN
TWISTED TOGETHER
1½ lb RIVETS
Nº 6 B.W.G. WIRE
Nº 16 B.W.G. WIRE
2 lb RIVETS
Nº 2 MALLEABLE KETTLE EARS
Nº 26 B.W.G. GALVANIZED IRON

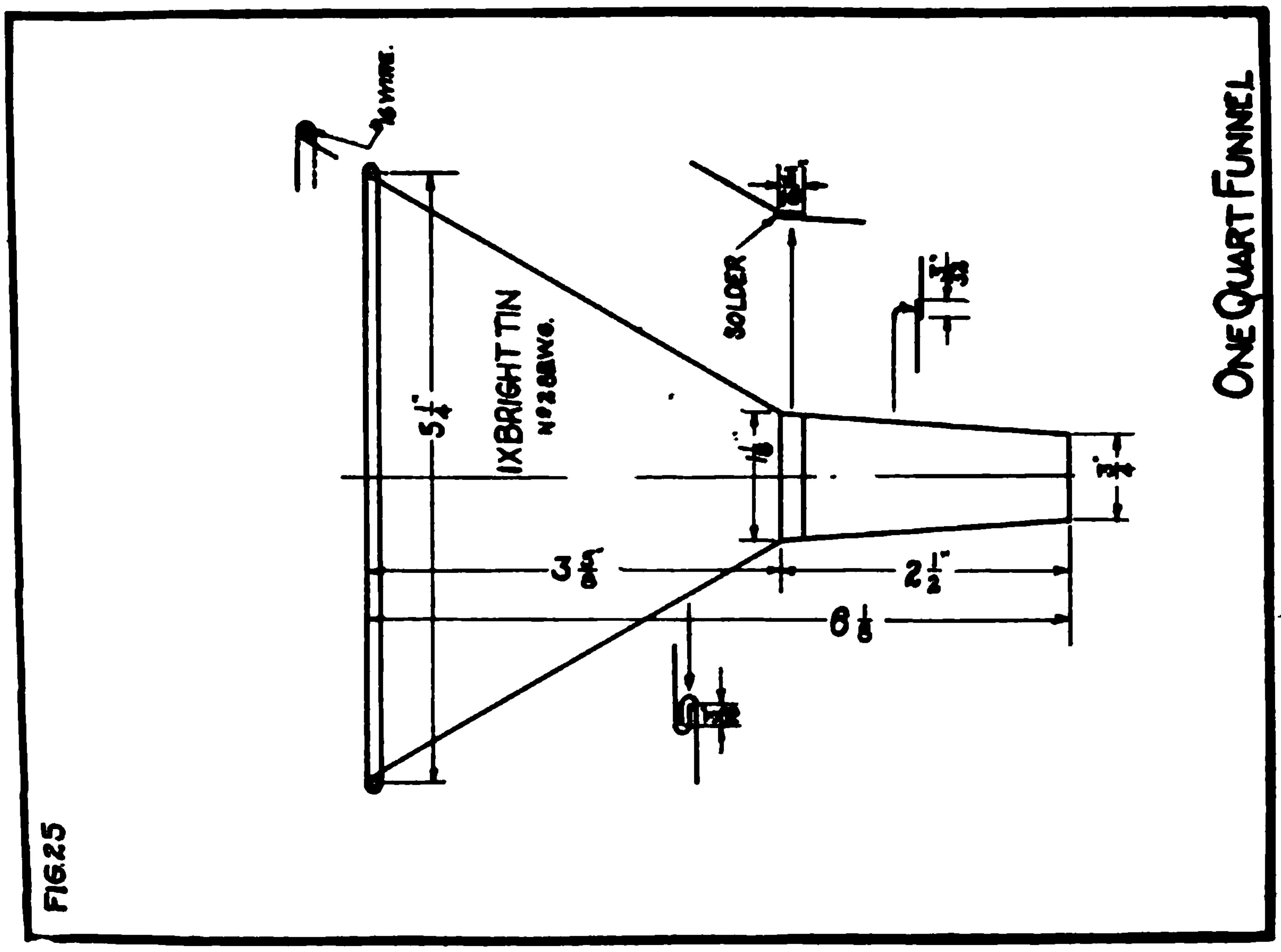


FIG. 25

ONE QUART FUNNEL

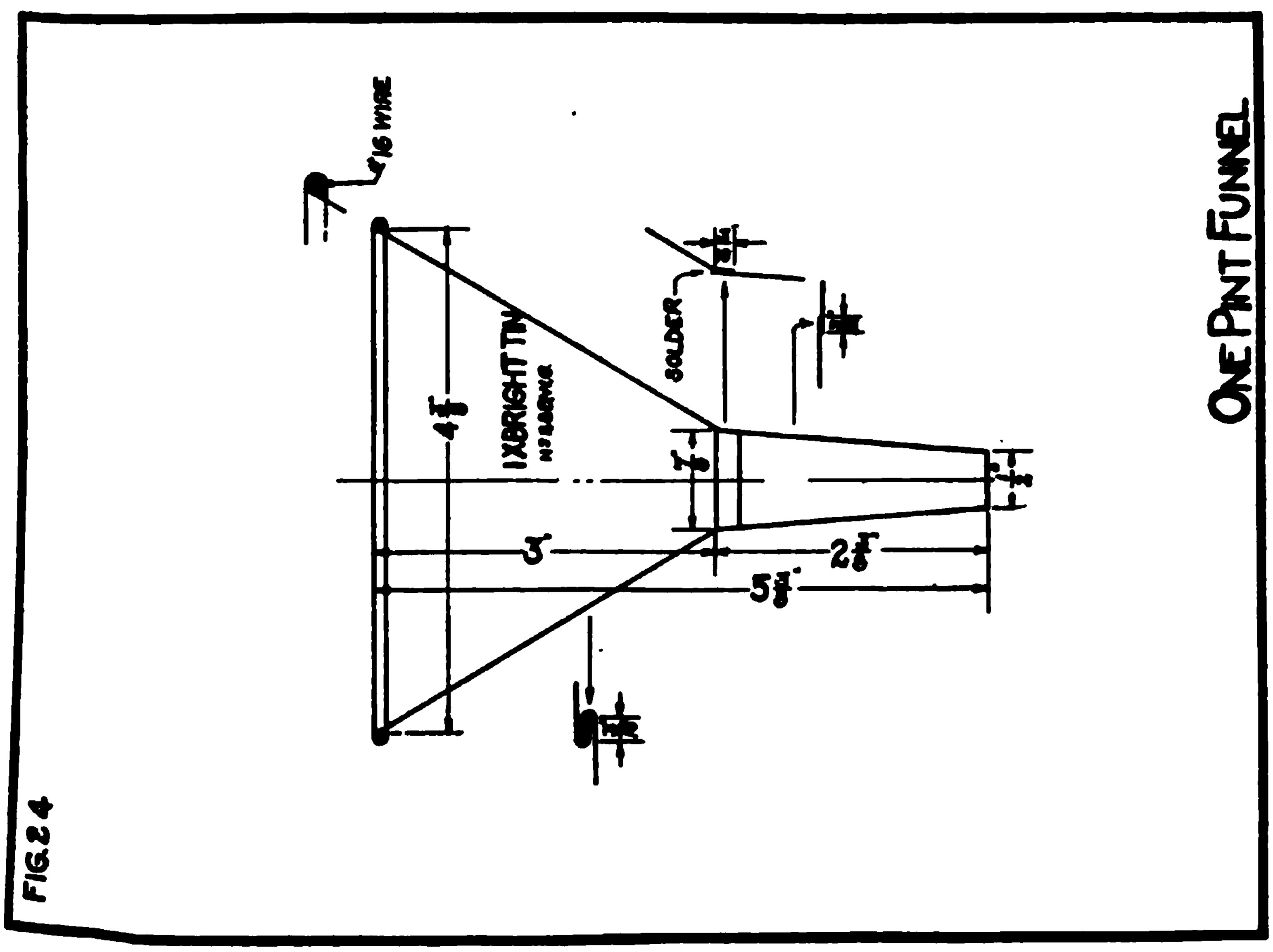


FIG. 24

ONE PINT FUNNEL

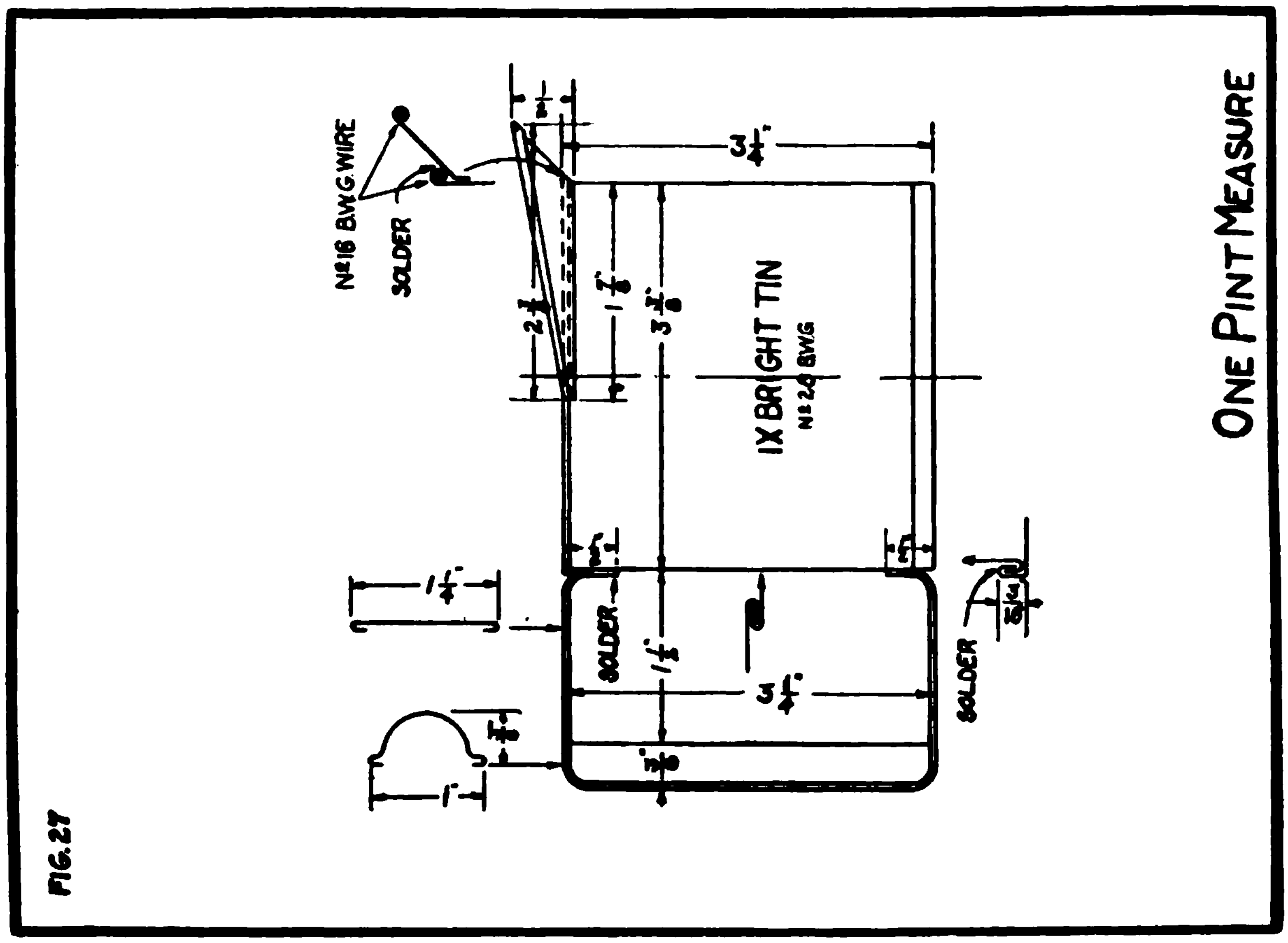


FIG. 27
ONE PINT MEASURE
IX BRIGHT TIN
No 28 B.W.G.
No 16 B.W.G. WIRE
SOLDER
SOLDER
SOLDER

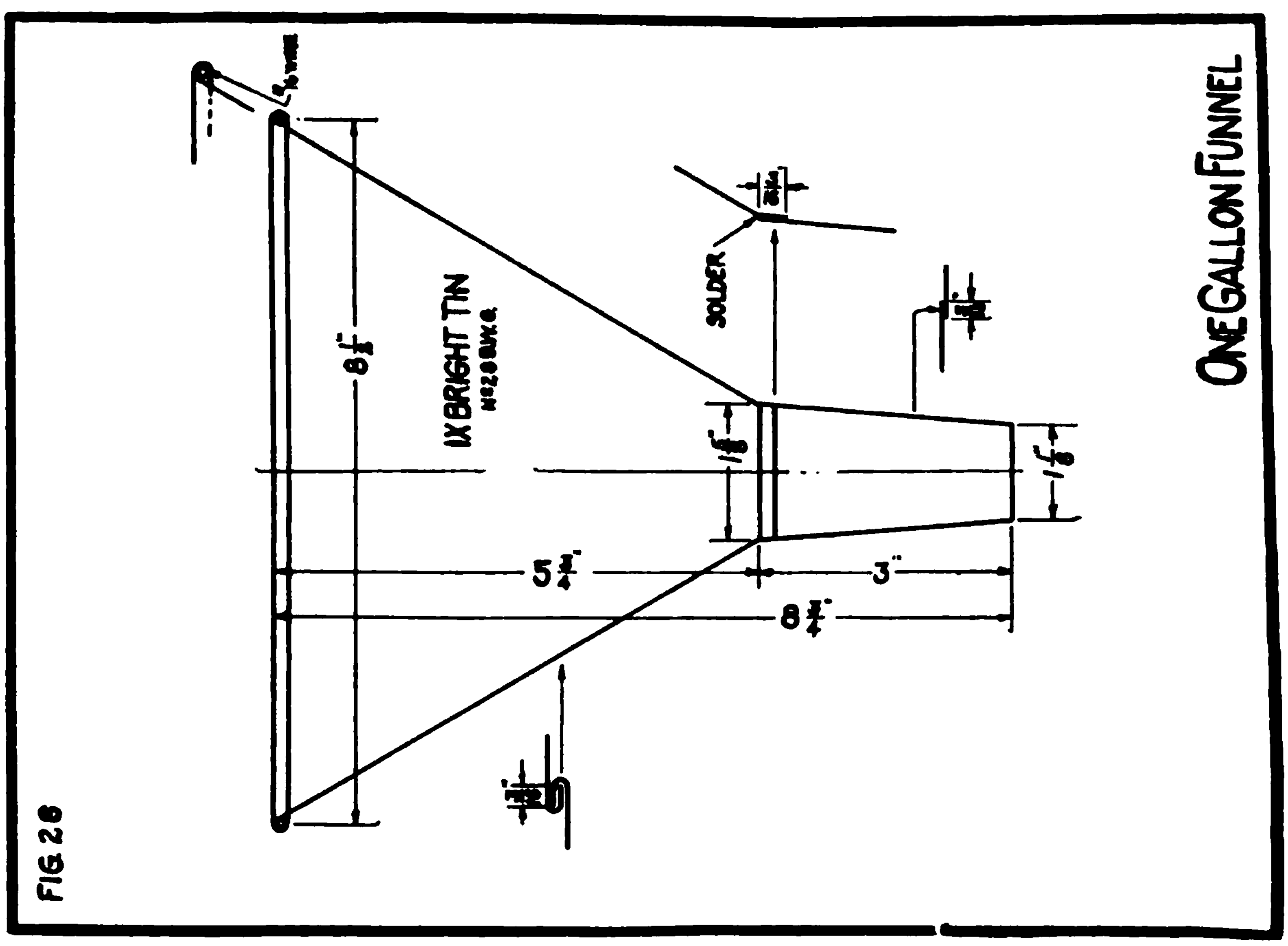


FIG. 28
ONE GALLON FUNNEL
IX BRIGHT TIN
No 28 B.W.G.
SOLDER

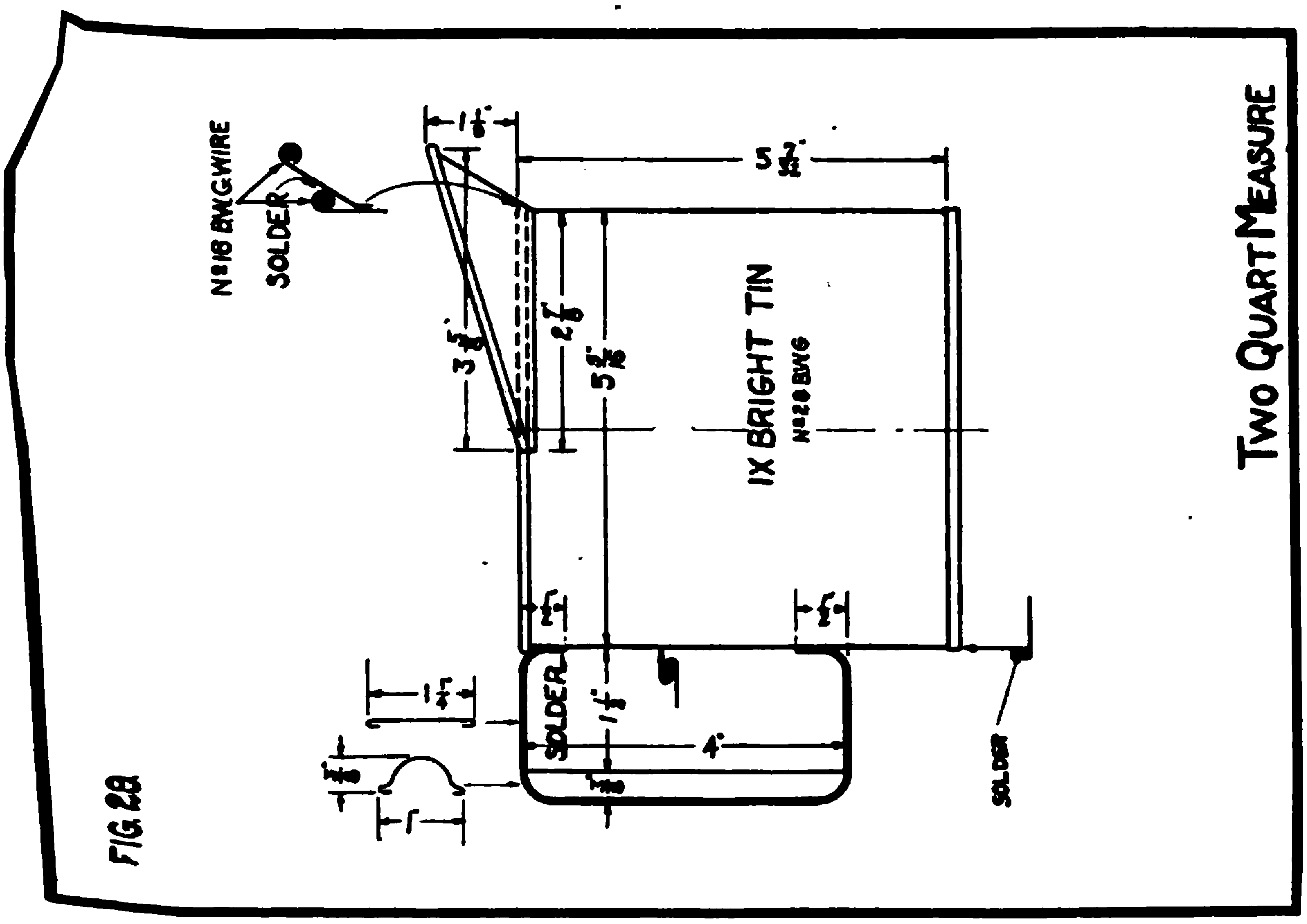


FIG. 29
No 18 B.W.G WIRE
SOLDER
IX BRIGHT TIN
No 28 B.W.G
SOLDER
4"
SOLDER
TWO QUART MEASURE

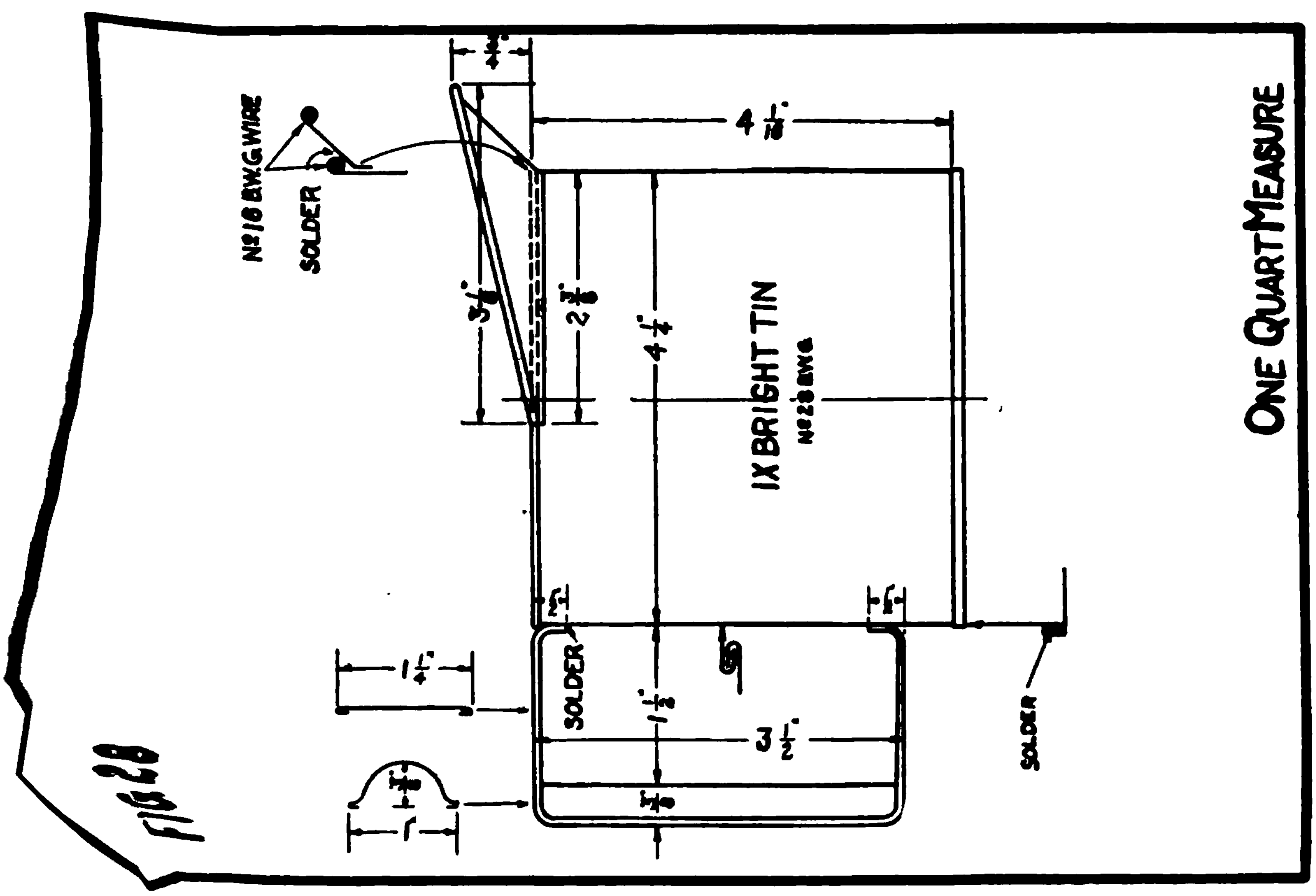


FIG. 28
No 18 B.W.G WIRE
SOLDER
IX BRIGHT TIN
No 28 B.W.G
SOLDER
SOLDER
ONE QUART MEASURE

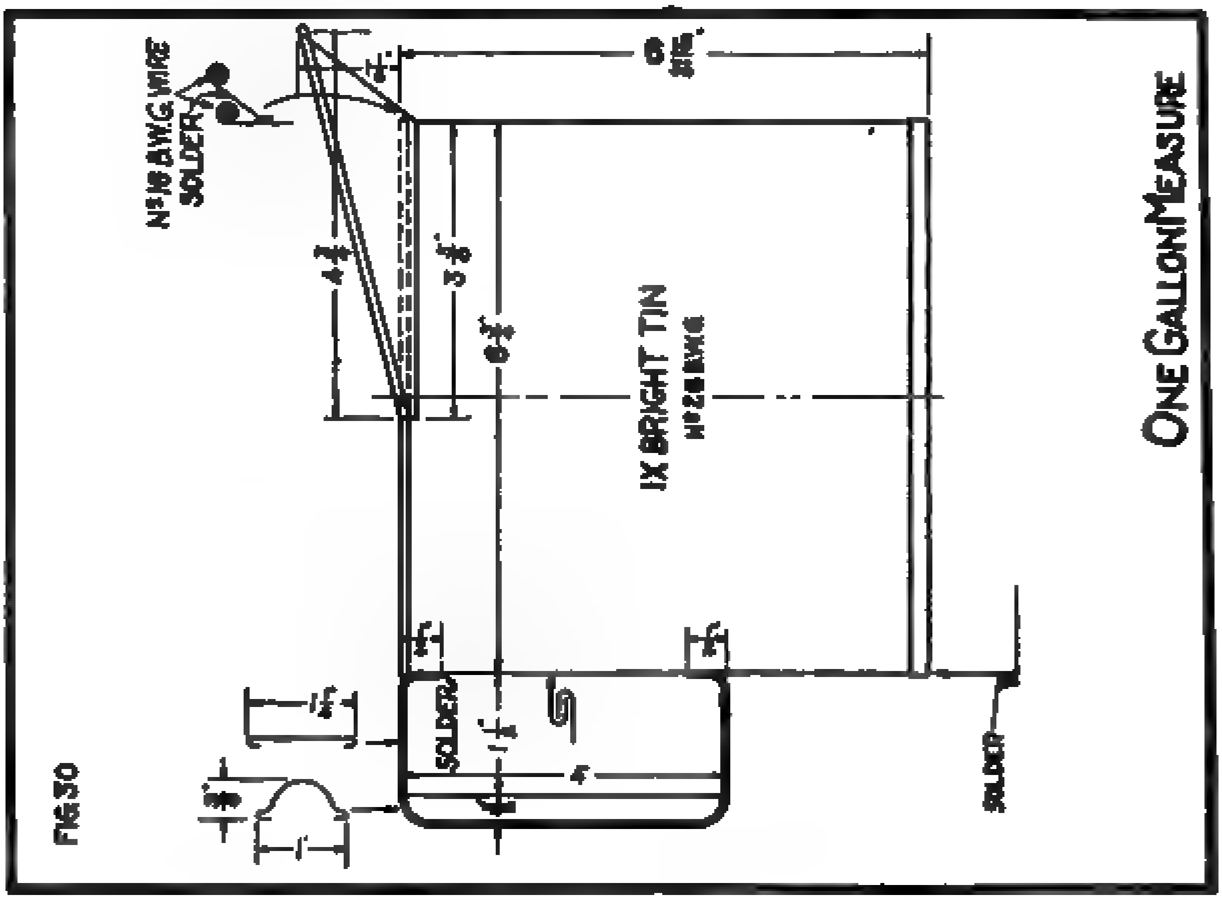


FIG 30
No 18 B.W.G. WIRE
SOLDER
IX BRIGHT TIN
No 28 B.W.G.
SOLDER
SOLDER
ONE GALLON MEASURE

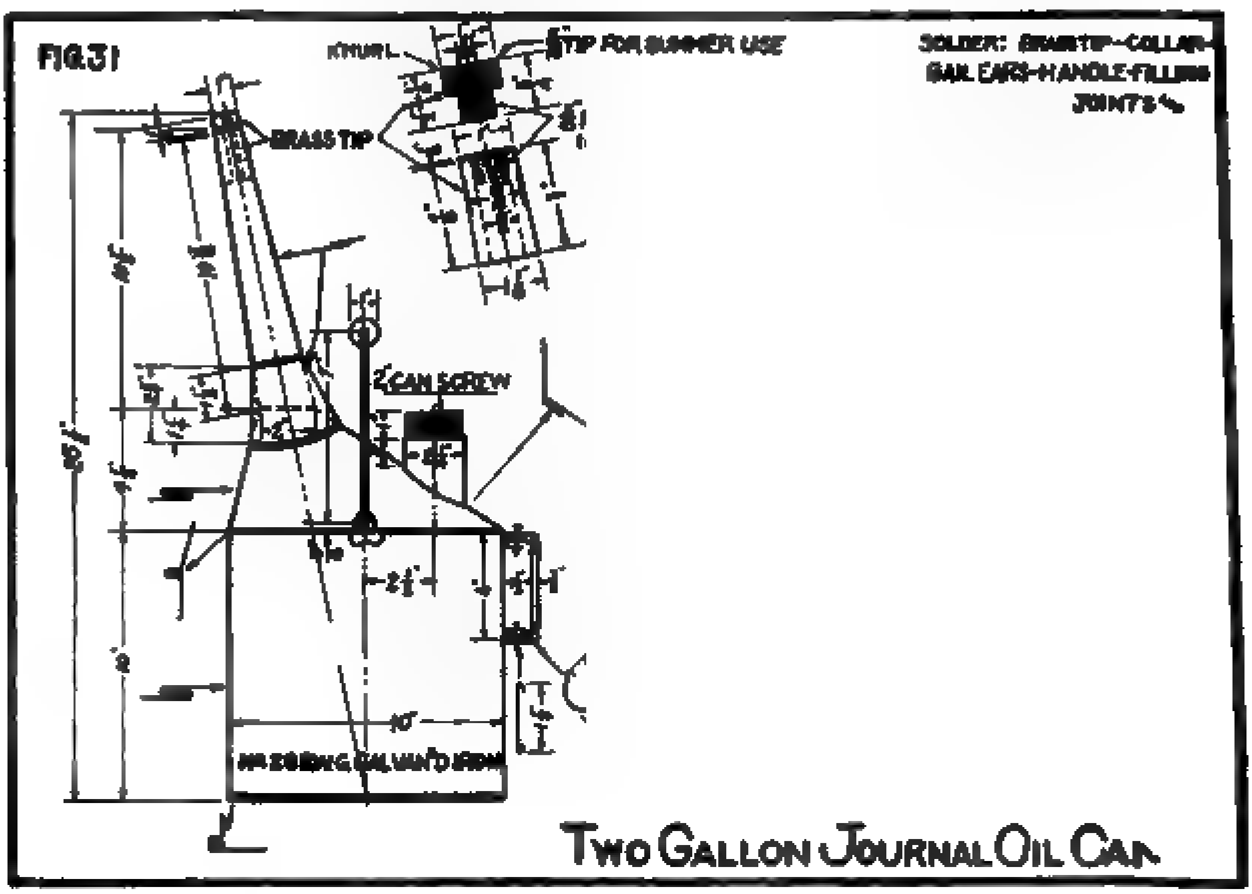


FIG.31
KNURL
TIP FOR SUMMER USE
BRASS TIP
CAN SCREW
SOLDER:
TWO GALLON JOURNAL OIL CAN

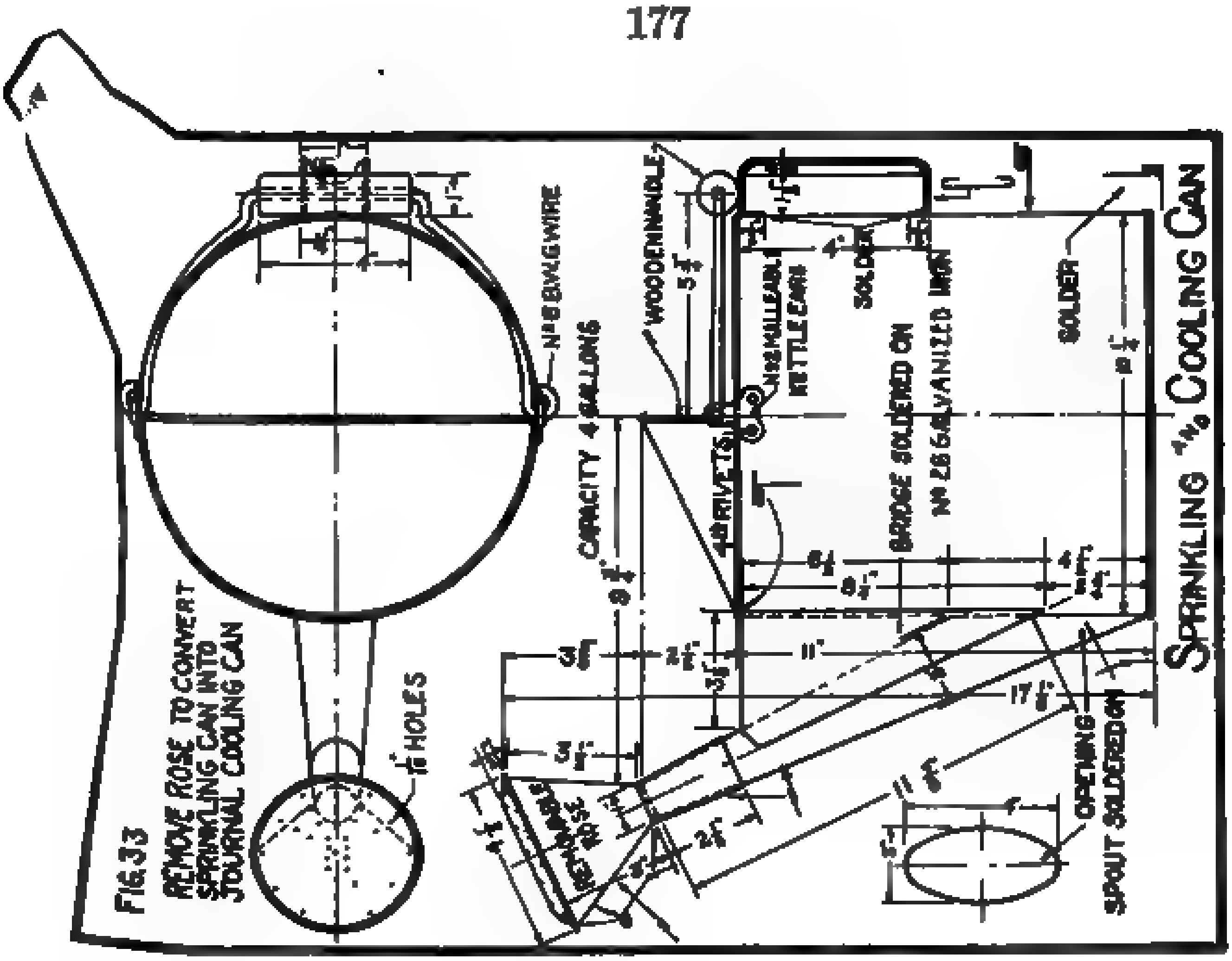


FIG. 33
REMOVE ROSE TO CONVERT SPRINKLING CAN INTO JOURNAL COOLING CAN
1/16" HOLES
CAPACITY 4 GALLONS
No 8 B.W.G. WIRE
WOODEN HANDLE
No 8 MALLEABLE KETTLE EARS
SOLDER
BRIDGE SOLDERED ON
No 26 GALVANIZED IRON
RIVETS
REMOVABLE ROSE
OPENING
SPOUT SOLDERED ON
SPRINKLING AND COOLING CAN

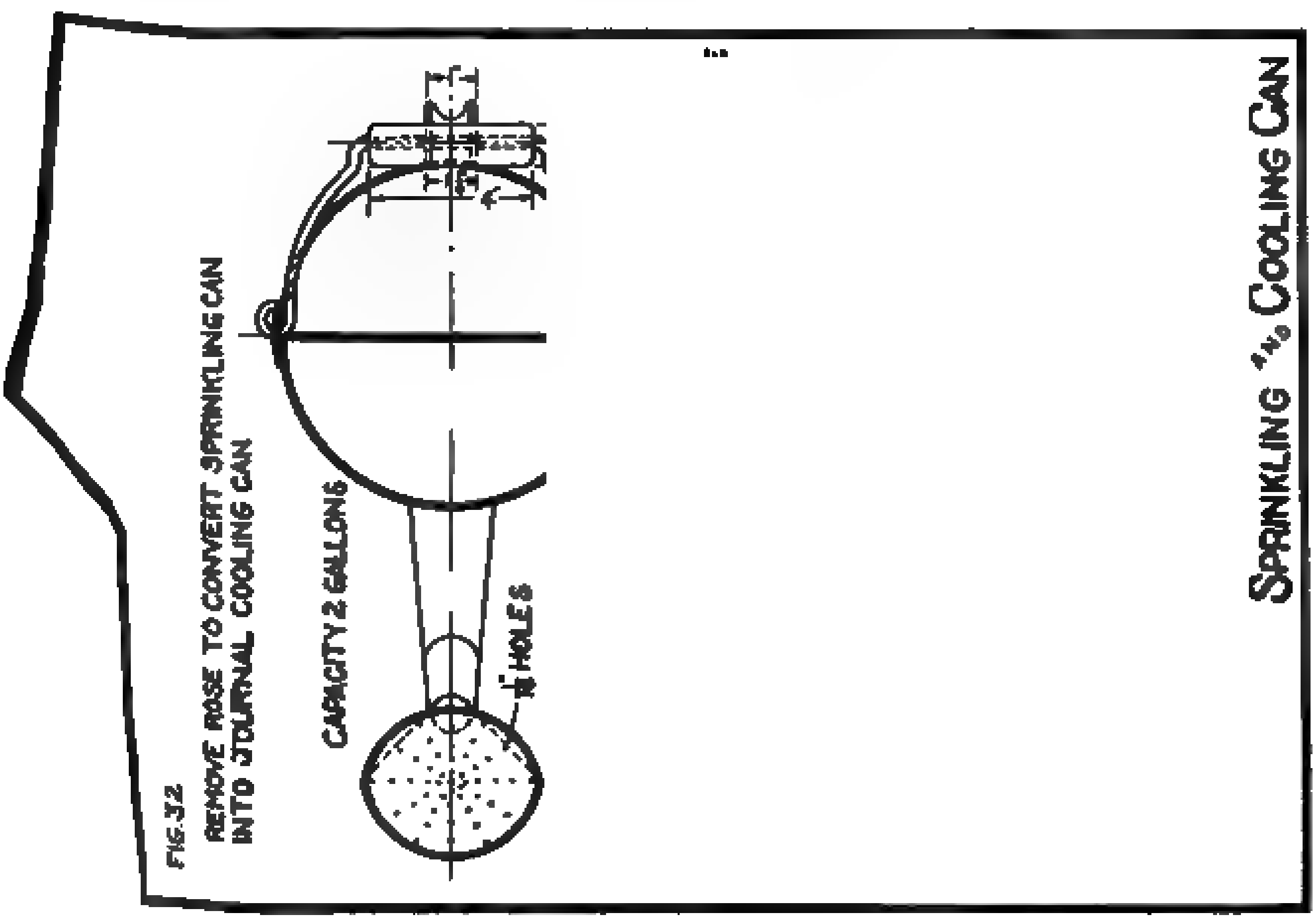
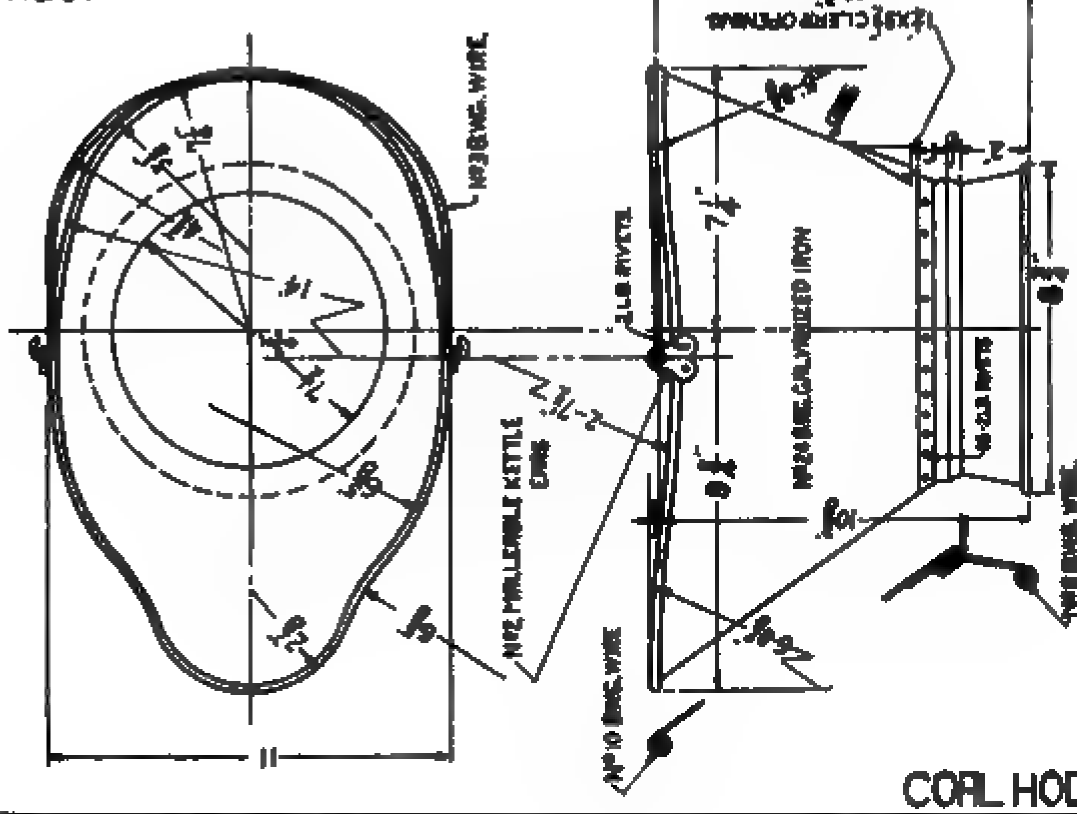


FIG. 32
REMOVE ROSE TO CONVERT SPRINKLING CAN INTO JOURNAL COOLING CAN
CAPACITY 2 GALLONS
1/16" HOLES
SPRINKLING AND COOLING CAN

FIG. 34



COAL HOD

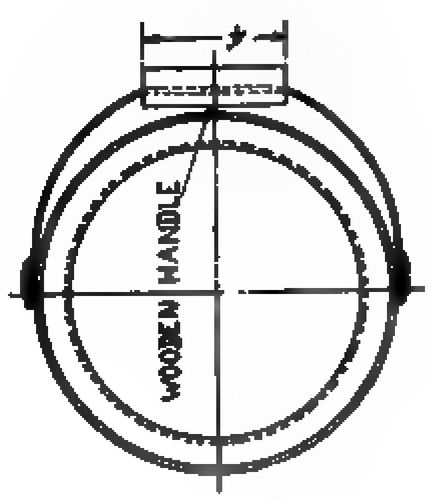


FIG 35

TWO GALLON PAIL

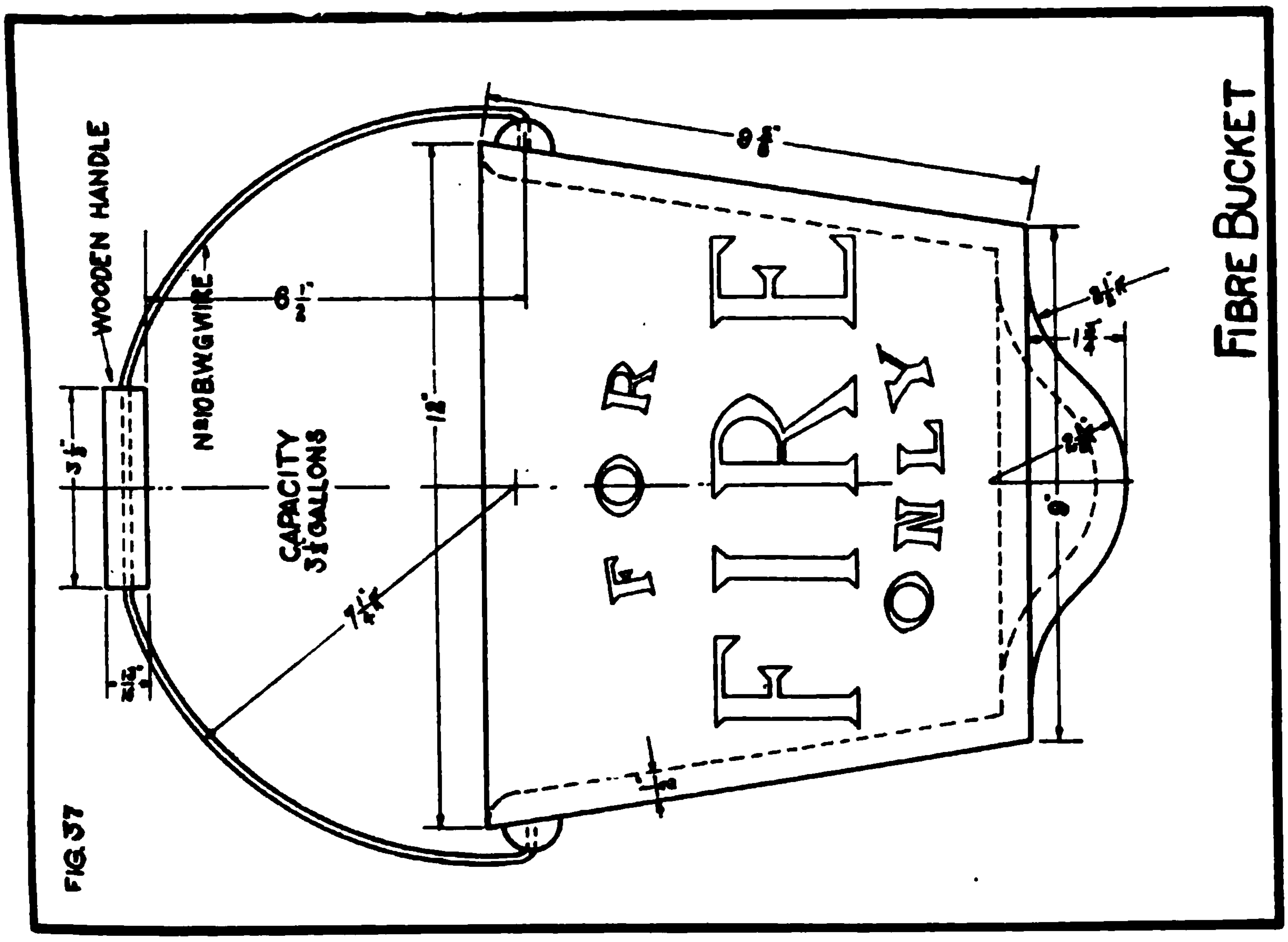


FIG. 37
FIBRE BUCKET
WOODEN HANDLE
No10 B.W.G. WIRE
CAPACITY 3½ GALLONS
FOR FIRE ONLY
12"
9"

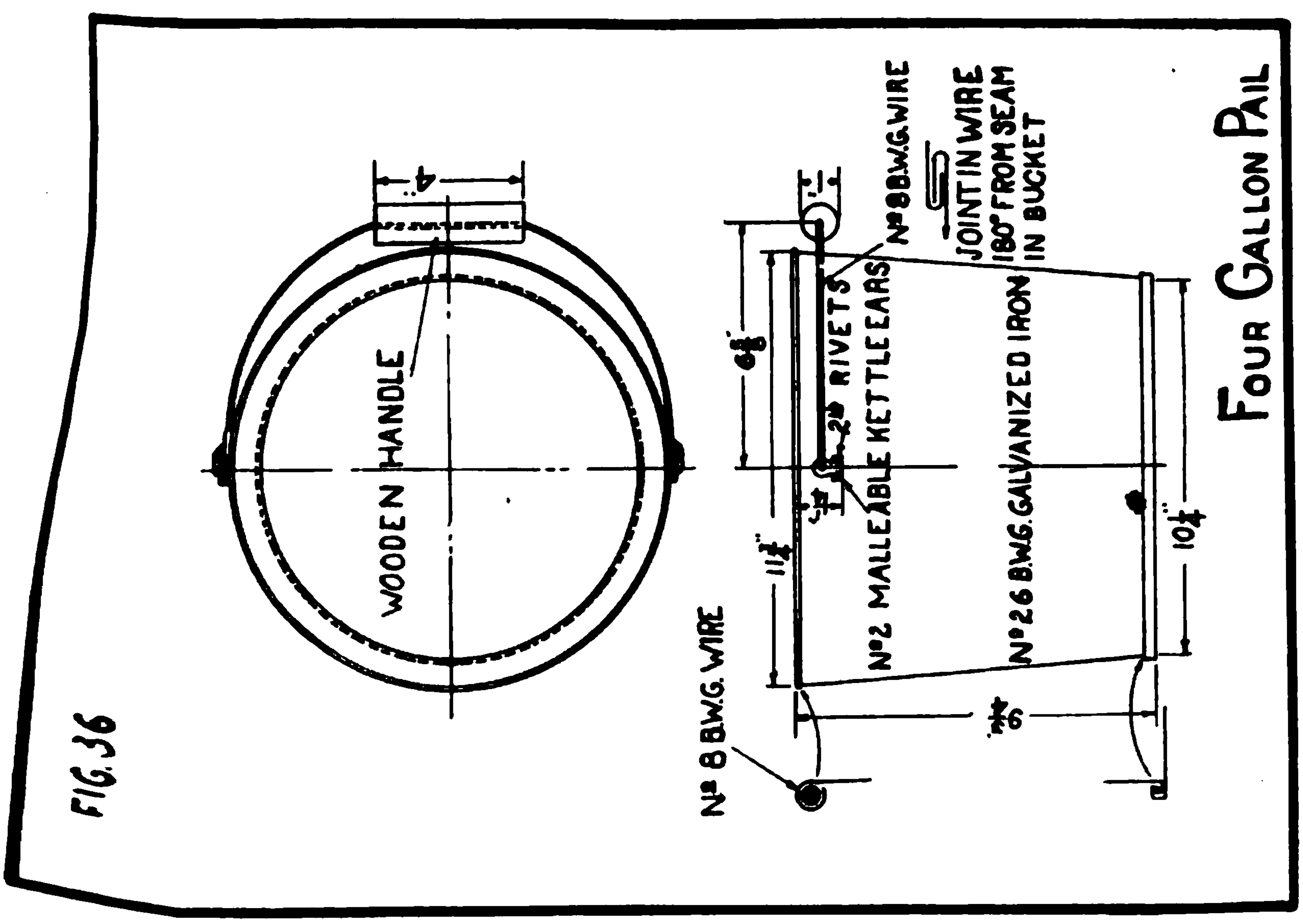


FIG. 36
FOUR GALLON PAIL
WOODEN HANDLE
4"
No 8 B.W.G. WIRE
RIVETS
No 2 MALLEABLE KETTLE EARS
No 26 B.W.G. GALVANIZED IRON
JOINT IN WIRE 180° FROM SEAM IN BUCKET
11¼"
10¼"

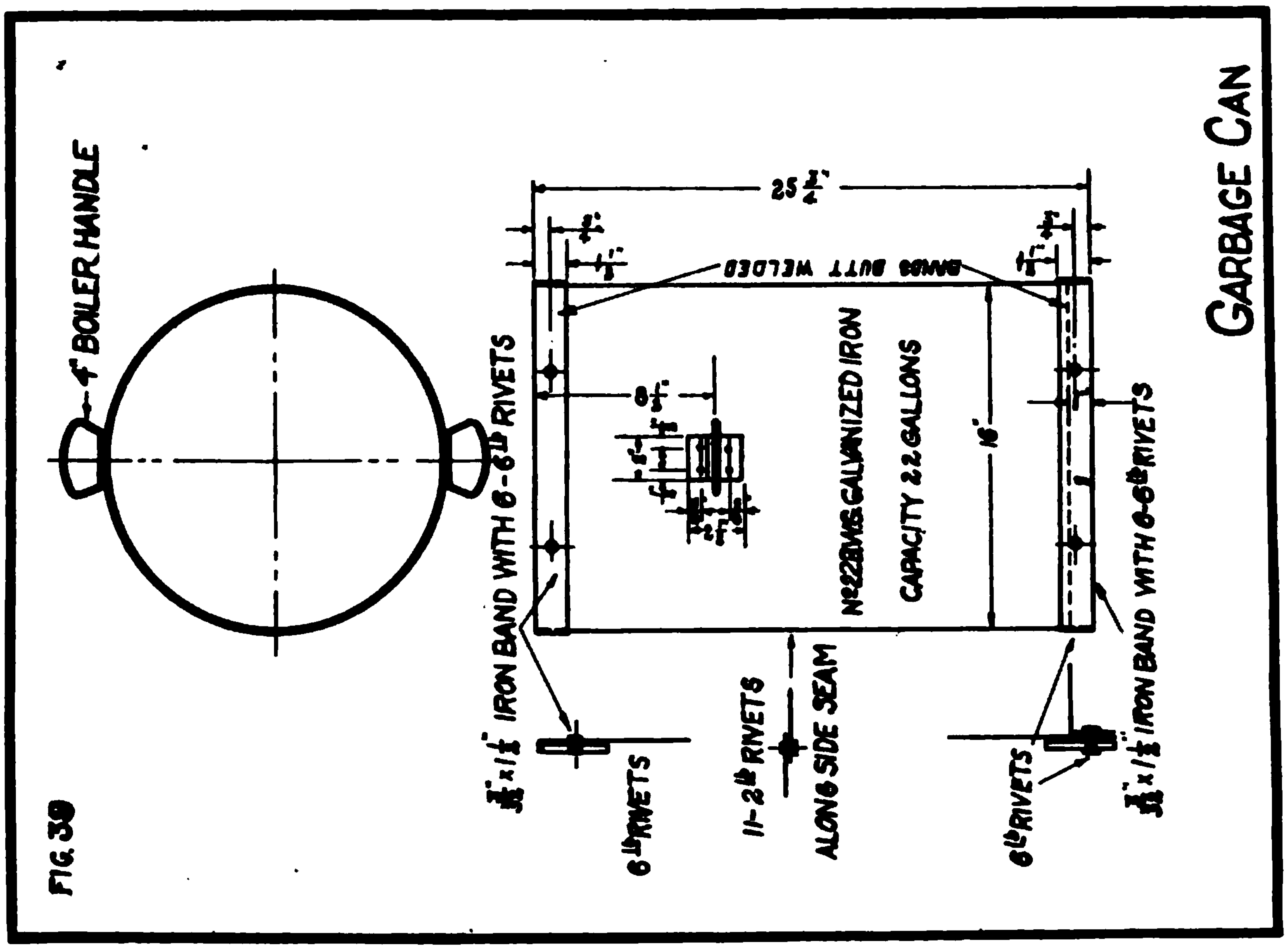


FIG. 39
4" BOILER HANDLE
25 3/4"
BANDS BUTT WELDED
16"
No 22 B.W.G. GALVANIZED IRON
CAPACITY 22 GALLONS
3/16" x 1 1/2" IRON BAND WITH 6-6 lb RIVETS
6 lb RIVETS
11-2 lb RIVETS
ALONG SIDE SEAM
GARBAGE CAN

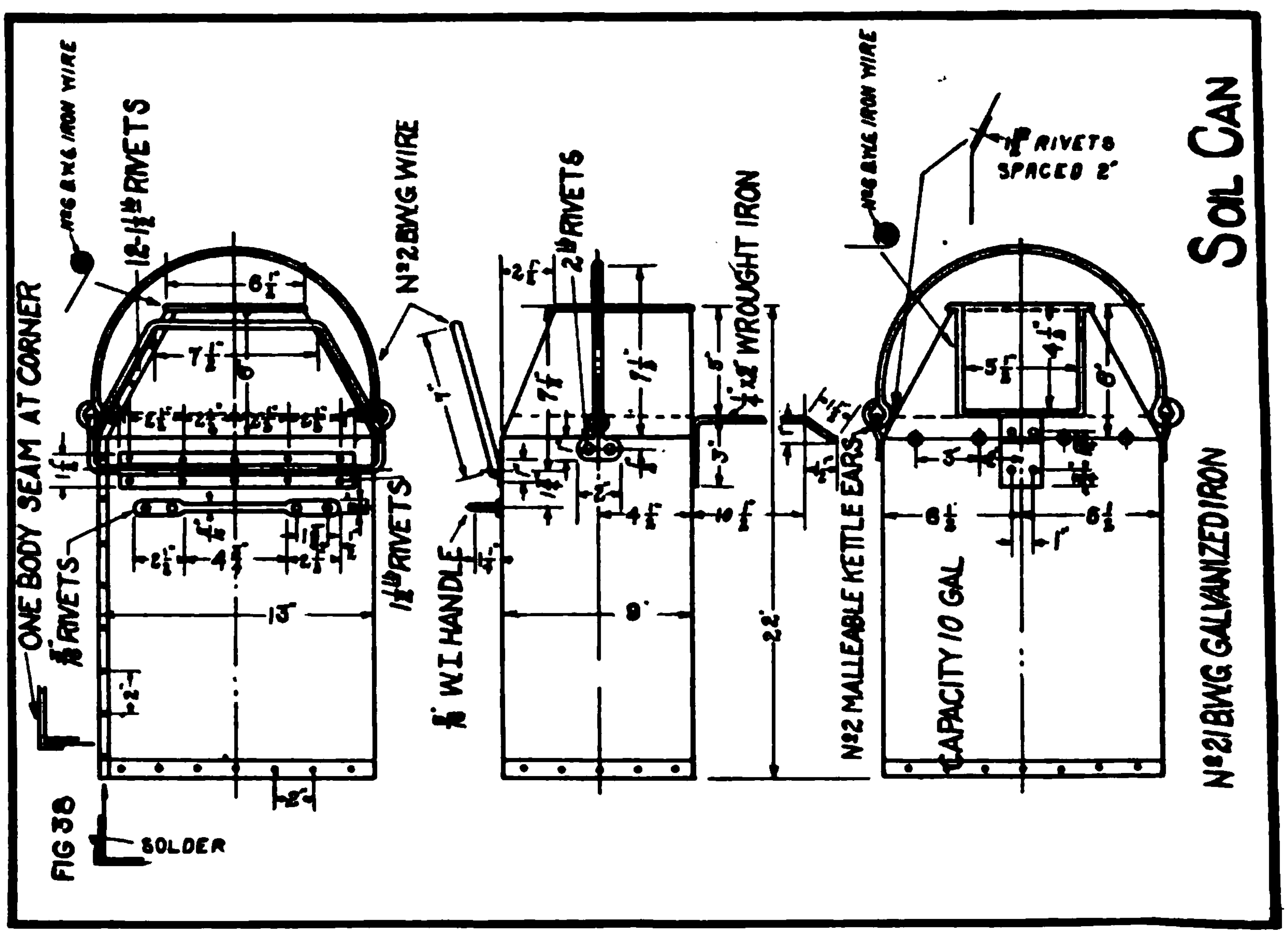
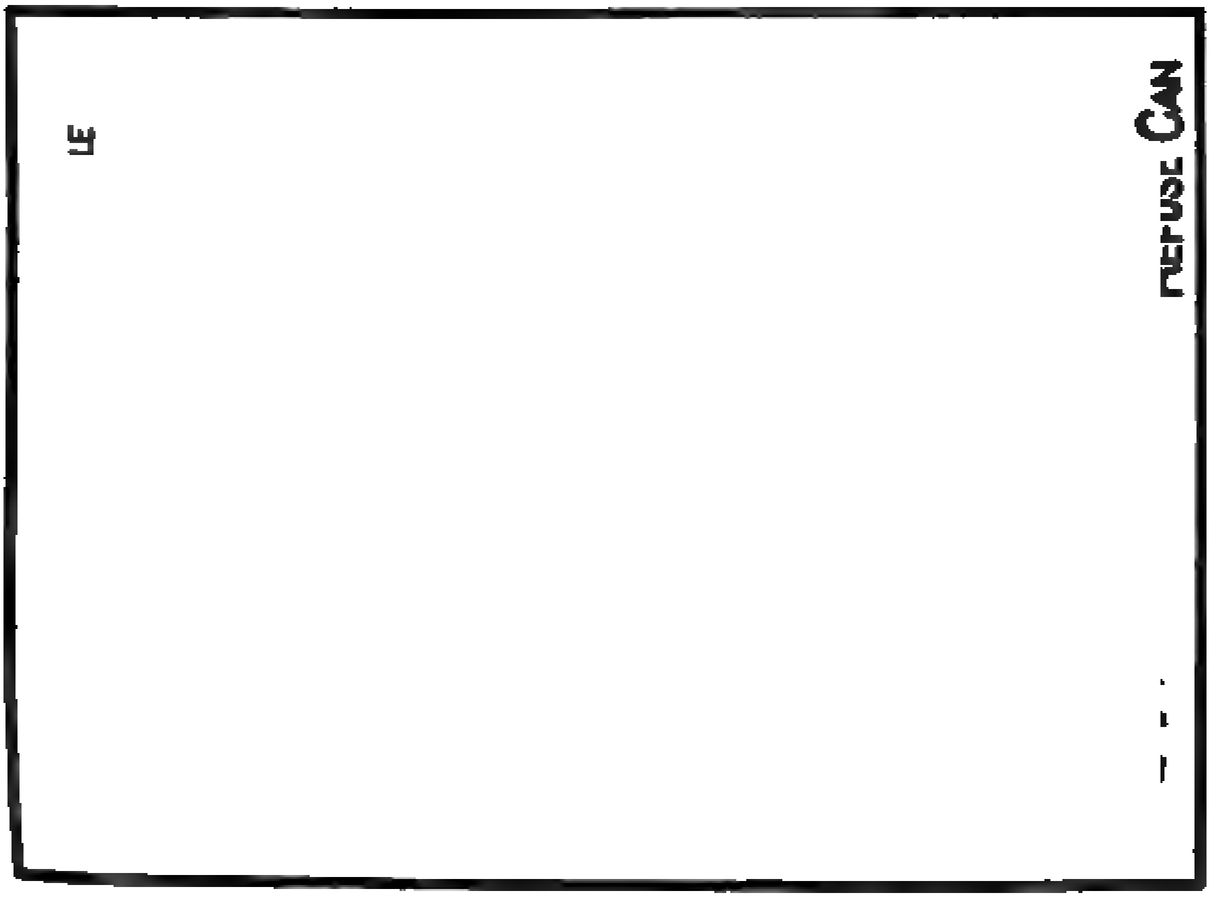


FIG 38
SOLDER
ONE BODY SEAM AT CORNER
3/16" RIVETS
12-1 1/2 lb RIVETS
N°2 B.W.G. WIRE
1 1/2 lb RIVETS
3/8" W.I. HANDLE
2 lb RIVETS
WROUGHT IRON
N°2 MALLEABLE KETTLE EARS
CAPACITY 10 GAL
N°21 B.W.G. GALVANIZED IRON
RIVETS SPACED 2"
SOIL CAN



ing of the valve oil before putting it in the can, so that it will readily strain through the perforations.

Fig. 8 shows a five-pint valve oil can, designed along the same lines, excepting the elliptical formation. The purpose of this form of construction is to give a large-capacity can, placing the handle on the side, enabling same to be used in a minimum of space between the lubricator and the roof of the cab.

Fig. 9, two-quart oil can, with double-folded seams.

Fig. 10, one-gallon can, of similar design. Both of these cans were made the same diameter, which will permit using the same dies in construction.

Fig. 11 is a two-gallon oil can, similar in construction to Figs. 9 and 10.

Fig. 12, three-gallon oil can, made of galvanized iron, has the bonnet so constructed as to permit of a free outlet for the oil. The iron band riveted to the flanged edge of the bottom protects the can from rough usage.

Fig. 13, five-gallon, and Fig. 14, ten-gallon, are constructed along similar lines.

Fig. 15 is a cheap form of card case that is fastened to the inside of the cab to hold the Federal Boiler Inspection card.

Fig. 16 is a form of card case, also nailed to the side of the cab, to receive the individual boiler-washout card. The dimensions of these may be varied to suit the cards used on the individual roads.

Fig. 17 is the two-gallon tank bucket referred to in the first part of this paper.

Figs. 18 and 19 show two designs of sand buckets, where such an article is necessary.

Fig. 20 is a recommended form of sponge bucket for engine-house use. This bucket has a capacity of four gallons or 50 lb. of saturated sponging. It is made elliptical for convenience in carrying, and will hold enough sponging to pack one side of a Pacific type engine, trailer and engine trucks. It is suggested that two buckets be used, one to contain the new sponging and one to receive the old waste removed from the boxes. The bucket is made large to avoid the frequent trips from the draining vat to the engine being packed. Since adopting the above bucket we have found it desirable to use a three-wheel truck or wheelbarrow of light construction large enough to carry two buckets and a set of tools for the doper. One bucket is used for the old sponging to be removed and the other bucket for the fresh sponging. This is a decided labor saver and prevents the operator making unnecessary trips to the dope vat.

Fig. 21 is a one-pound emery can, with a small opening which directs the emery onto the spot where it is required. There is a remarkable saving in the amount of emery used with a can of this type.

Fig. 22, a universal form of marking pot.

Fig. 23, a convenient and sanitary form of dustpan.

Figs. 24, 25 and 26, three sizes of funnels, which should take care of all requirements in the mechanical department.

Figs. 27, 28, 29 and 30, one-pint, one-quart, two-quart and one-gallon measures. These measures are made with parallel sides to economize in labor and material.

Fig. 31, two-gallon oil can, with removable brass tip so that the size of hole may be varied as required. The use of this oil can is not recommended in engine houses.

Figs. 32 and 33 show two forms of sprinkling cans, which may also be used for cooling cans, if desired, by removing the rose; this with a view of reducing the number of parts necessary to carry in store stock.

Fig. 34, a plain and economical form of coal hod.

Fig. 35, two-gallon pail.

Fig. 36, four-gallon pail.

Fig. 37, fiber fire bucket. These buckets are cheaper than the metal buckets, and will more readily withstand the corrosive action of salt and water. Where salt is not used in the water, some members prefer sheet-metal buckets, and we have placed a note on the drawing to cover this.

Fig. 38, a form of soil can that is used by some of the railroads where Pullman car and private cars are required to stand in the terminal while occupied.

Figs. 39 and 40, garbage and refuse cans, shown with and without cover.

M. D. Franey, Chairman,
J. C. Mengel,
W. C. Hayes,
G. S. Goodwin,
W. O. Moody,
Committee.

The following letter has been received this morning by the Tinware Committee of the Master Mechanics' Association:

"Gentlemen,— We respectfully ask that your good committee, in justice to several railroads which now, or may in the future, desire to use tinware made from other materials than tin plate, that your committee makes its report to read that the different articles can be made of either tin plate, galvanized iron or steel, so long as the general sizes, styles, dimensions and capacities are conformed to.

"Respectfully submitted,
"The Eagle Glass & Mfg. Co."

This company has an exhibit at space No. 200, and Committee on Standardization of Tinware requests that the members examine this exhibit, as well as that of the tinware.

Mr. Franey: The committee found in their replies that most of the blue-prints referred to what is known as IX bright tin. It is the opinion of the committee that this is the custom handed down, and it is not necessary for us to confine ourselves to the use of this tin. There are cheaper grades which would probably serve the purpose just as well. We also found that certain roads were using a line of articles manufactured from steelware, though we did not get enough information as to the final cost of these articles to justify us in making a recommendation.

Through the courtesy of the Johnson Manufacturing Company, which I believe I am justified in giving credit, the committee have been enabled to present for the inspection of the members samples of the tinware which the committee has recommended. These have been furnished gratis, and many of you have seen the exhibit in the adjoining building in the booth of the American Car & Foundry Company, and we would respectfully request the

members who have not looked at this tinware as yet to examine it and give us their criticisms.

I will say that we have found it desirable to use a three-wheeled truck or wheelbarrow of light construction, and use two buckets in engine-house service, one for receiving the old sponge and one for receiving the new, and the man in charge of the truck is also instructed to carry the necessary tools and a brass, if necessary for the operator. It prevents the operator from making what we might term "light mileage" through the roundhouse.

THE PRESIDENT: Gentlemen, you have heard the report of the Committee on the Standardization of Tinware. Unless there is some objection it will be received and opened for discussion.

MR. BARNUM: I move, Mr. President, that the committee's report be received and the recommendations submitted to letter ballot. It seems to me that the subject has been very thoroughly covered, and it is a very comprehensive report.

The motion was seconded and carried.

THE PRESIDENT: The next business in order is the report of the Committee on Superheater Locomotives, of which committee Mr. H. H. Vaughan is chairman.

THE SECRETARY: We have not received a written report from the Committee on Superheater Locomotives. I have a letter from Mr. Vaughan, the chairman of the committee, which I will read.

MONTREAL, CANADA, May 21, 1915.

Mr. Joseph W. Taylor, Secretary, American Railway Master Mechanics' Association, Karpen Building, Chicago:

DEAR MR. TAYLOR,— I am sorry to say that I will be unable to make any report on the locomotive superheaters at the coming convention. In the first place, I do not know what to report, as it seems to me that the subject has been pretty well covered already, and that there have been no improvements during the past year. In the second place, I have been sufficiently engaged on other matters that I absolutely did not have time to go into this work. This is a new and exceedingly unsatisfactory condition, but I think that until the last few weeks I have had practically nothing to report on the superheater question, and that the Association will probably forgive me for my negligence in view of the large amount of time I have devoted to this subject in the past.

I have just received from Mr. Wallis a copy of a pamphlet, P. R. R. No. 27, giving results obtained from the Class E-62 engines with length-

ened tubes and cylinders increased to 23½ inches in diameter. I am sending you a copy of this pamphlet, and would ask you to submit it to the Executive Committee to see whether they would deem it desirable to incorporate this bulletin into a report from the Superheater Committe. Our proceedings have in the past included most of the important published experiments on the Pennsylvania Testing Plant, and as this is an important addition to preceding experiments, it might be considered well worth our while to abstract it to a certain extent and print it as a report from the Superheater Committee. I have made an attempt at abstracting it and have drawn a pencil line opposite such paragraphs and illustrations as I think it desirable to reproduce. There is a question in my mind whether it is worth while abstracting it at all, although we may leave out the portion after page 84. If the Executive Committee think it desirable to print this, it will be easy to draft a short report introducing it, and as the report is evidently of great value, I feel that such a course would be desirable. Yours very truly,

H. H. VAUGHAN.

The Executive Committee at its meeting Tuesday night suggested that this pamphlet be incorporated in the Proceedings of this convention, if authority can be obtained from the Pennsylvania Railroad Company.

THE PRESIDENT: You have heard the letter from the chairman of the Committee on Superheater Locomotives, which the Secretary has read. I will say personally that I do not think we should drop this committee. There are developments going on in superheater work all the while, and some committee on superheater work should be continued. A motion to that effect would be in order.

MR. PRATT: I make that motion, and in view of Mr. Vaughan's letter and the change in his line of work, and also in view of the very strenuous work which he has put in on this committee for a great number of years I think it is no more than fair that he should be relieved of the chairmanship of this committee, and perhaps of membership on the committee. I am sure he will appreciate it, and I am also sure that we very much appreciate the work he has done for this Association on that committee.

Motion put and seconded.

The report is as follows:

LOCOMOTIVE TESTING PLANT TESTS OF A CLASS E6s PASSENGER LOCOMOTIVE.

A Very Powerful Atlantic Type Superheater Locomotive with Large Cylinders.

1. The Atlantic type locomotive is a very desirable one for passenger service as compared with the Pacific. It is more flexible, due to its wheel arrangement and, having a smaller number of parts, it runs with less friction than the Pacific type and can in consequence haul trains which are

ATLANTIC TYPE PASSENGER LOCOMOTIVE No. 6056.

Pennsylvania Railroad Company, Class E6s (Superheated Steam), a locomotive of the same class as No. 51 which was used in the tests.

heavier in proportion to its own weight than is possible with other types. In recognition of these desirable qualities the locomotives of the E6 class, Atlantic type, have been the subject of a long and very thorough investiga-

tion and many tests, resulting in a perfection of design which is now showing remarkable results; and as advantage has been taken of all promising means of increasing the efficiency of these locomotives, their field of satisfactory operation has been much extended.

2. Laboratory or testing-plant tests have had a considerable influence upon the development of our locomotives, and consistent results have followed when the improvements suggested by the tests have been applied. That the test plant has been of service is especially noteworthy in the case of this class, where design changes have been made based upon earlier tests, as the Atlantic type has received much attention aside from test-plant work, and increases in its efficiency and power have been especially difficult to obtain on account of its former degree of perfection when compared with other types. Many railroads have discarded the Atlantic locomotive and have taken up the Pacific and other types for heavy passenger work instead of devoting the extreme care necessary for the improvement of the Atlantic type, which has, as we have noted, features too valuable to be abandoned.

3. Since the tests of the earlier E6s locomotive of 1912 which are described in Bulletin 21, the principal changes that have been made in the locomotive are: An increase in the length of tubes from 13 ft., 8⅝ in., in the older form, to 15 ft. in the new; cylinders enlarged from 22 in. to 23.5 in. in diameter without a change in the length of stroke; a new method of equalization and a remodeled valve gear having lighter parts than in the old form and with a screw reversing arrangement in place of the lever; a new crosshead, piston and rod which have been designed with the object of reducing the weight of the reciprocating parts.

4. The general dimensions of the two locomotives of the E6s class are as follows:

	Old E6s-89.	New E6s-51.
Total weight in working order, pounds	234 200	240 000
Weight on drivers, working order, pounds	141 000	133 100
Cylinders (simple), inches	22x26	23.5x26
Diameter of drivers, inches	80	80
Heating surface, tube (water side), square feet.	2 404.90	2 634.50
Heating surface, firebox, including arch tubes, square feet	254.48	232.74
Heating Surface, superheater (fireside)	688.81	810.6
Heating surface, total (based on water side of tubes), including superheater, square feet	3 348.19	3 677.8
Heating Surface, total (based on fireside of tubes), including superheater, square feet	3 089.49	3 405.6
Grate area, square feet	55.23	55.79
Boiler pressure, pounds per square inch	205	205
Valves, type	14-in. piston	12-in. piston
Valve motion, type	Walschaerts	Walschaerts
Firebox, type	Wide, Belpaire	Wide, Belpaire
Tubes, number	242	242
Tubes (outside diameter), inches	2	2
Flues (for superheater), number	36	36
Flues (outside diameter), inches	5.375	5.375
Tubes, length inches	164.63	179.71

Fig. 1.
GENERAL ARRANGEMENT.
Class E6s Locomotive.

Fig. 2.
END ELEVATIONS AND CROSS SECTIONS.

The maximum calculated tractive effort at starting is 29,427 lb. with eighty per cent of the boiler pressure available as mean effective pressure in the cylinders. This is equal to 179.43 lb. pull per pound of mean effective pressure. The ratio of weight on drivers to the calculated maximum tractive effort is 4.5.

Boiler.

5. Our own tests and those of other experimenters, have indicated that if the boiler tube is increased in length without an increase in diameter, there is a point beyond which the lengthening of the tube fails to produce a proportional increase in evaporation, the effect being partly due to the increasing resistance to the flow of gases and the consequent retardation of combustion in the firebox. For best results, however, the tubes should be extended fully up to the point where the increase in evaporation ceases to be proportional to the increase in length.

6. According to our best judgment, the most desirable length for the tube is close to 100 times its internal diameter, and this rule has been tentatively adopted.

7. With the first E6 boiler the tubes were somewhat short of this most desirable length; having a ratio of 94. In the new boiler the tubes have been lengthened to 15 ft. with a ratio of length to diameter of 103. This is a small change, but in addition to the good results shown the 15-ft. tubes have the advantage of being uniform in length with those of a number of locomotives of other classes.

8. In the new boiler there have been no changes of importance except in the tube length. The new boiler has a heating surface (fireside) of 3405.6 sq. ft., and a grate area of 55.79 sq. ft. The outside diameter of the boiler at the front end is 78½ in. and 83½ in. at the dome. There are 242 2-in. tubes and 36 5⅜-in. superheater flues. The combustion chamber, while it still exists in these boilers, is comparatively short. The boiler is fitted with a brick arch carried on three water tubes.

Valves and Valve Gear.

9. Highly superheated steam is a more attenuated or rarified gas than saturated steam of the same pressure, and it has been found to flow through steam passages with much greater freedom, making it possible therefore to somewhat restrict the usual passages through the valves by a very desirable reduction in their diameter. The valves are now 12 in., where in the former locomotives they were 14 in. in diameter.

10. There has, in fact, been a complete revision of the whole scheme of piston valve and valve gear arrangement in an effort to produce lighter stresses in the valve gear, and less weight upon the valve surfaces, which are lubricated with greater difficulty with superheated than with saturated steam.

11. The valve gear, Fig. 8, in its new and lightened form appears to have very much greater rigidity than before, or it shows less change in the

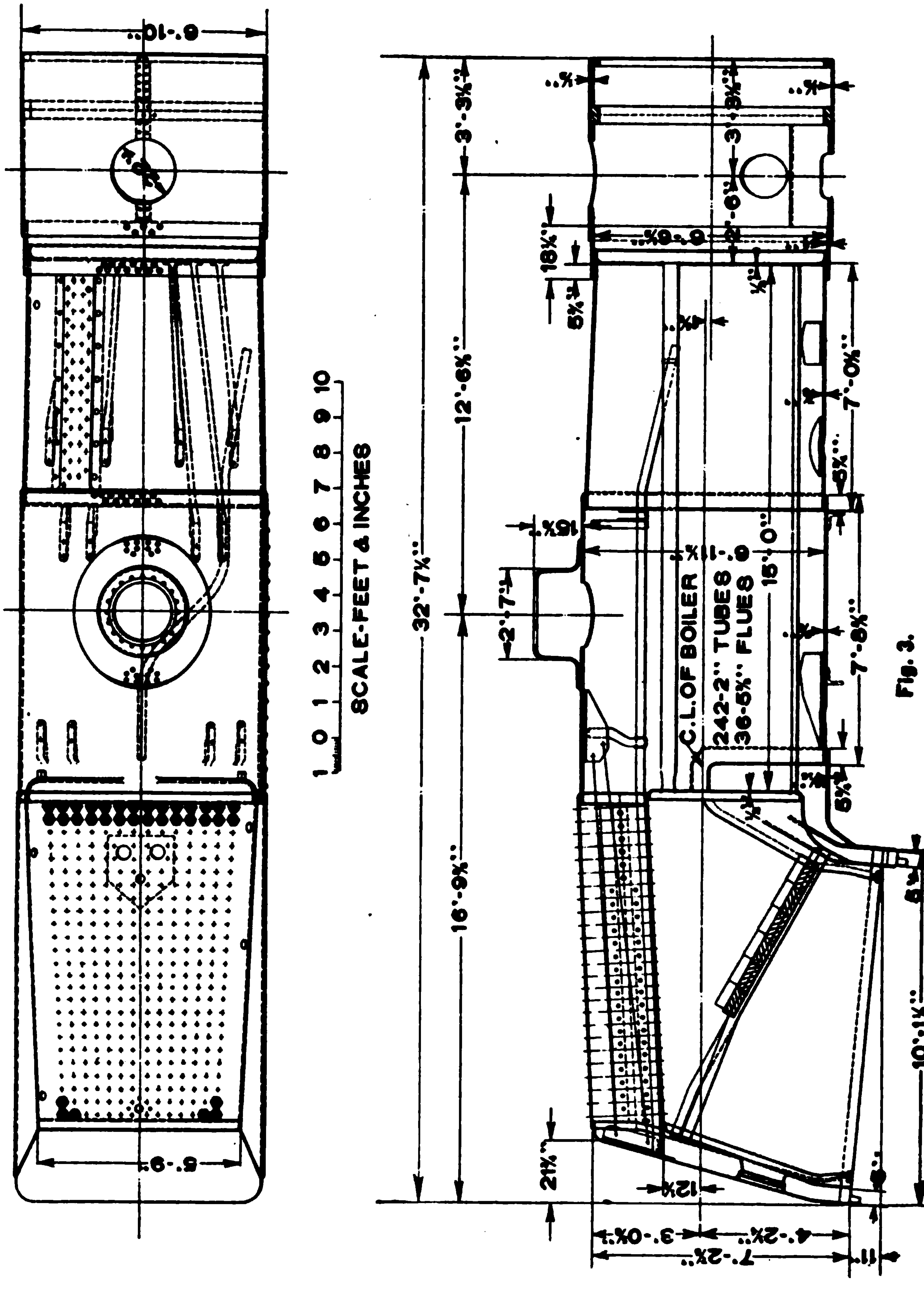


Fig. 3.
BOILER.
This is the largest boiler ever applied to an Atlantic type locomotive. It is fitted with a superheater and brick arch.

valve events with an increase in speed. To provide a convenient means of operation and adjustment, the screw reverse has been adopted for the new gear The lap and lead lever is shortened and its lower end is connected to the center of the crosshead.

12. A new form of valve steam crosshead is used, and an extension of the back head of the steam chest forms the guides. The wearing sur-

Fig. 4.
TUBE SHEETS.
There are 242 tubes 2 inches in diameter and 15 feet long and 36 superheater flues 5½ inches in diameter.

faces have renewable brass liners held in place by one bolt at the middle of each.

13. The valves, Fig. 9, are of the piston type with "anchored L rings." They are made of a steel tube and bell-shaped pieces welded on the ends. The followers, carrying the rings, are of drop-forged steel. There is, in addition, a separating ring between the valve rings. The valve rings are of cast iron and are made with a flange on the inside, forming what is termed an "anchored L ring." The purpose of this flange is to hold in position any portion of a ring, should breakage occur. The rings are lapped past each other where the ends join, and the joint in the rings is at the top of the valve.

Piston and Piston Rod.

14. A new and light form of piston and rod has been designed for this locomotive, and is shown in Figs. 8 and 13. The piston rod forging

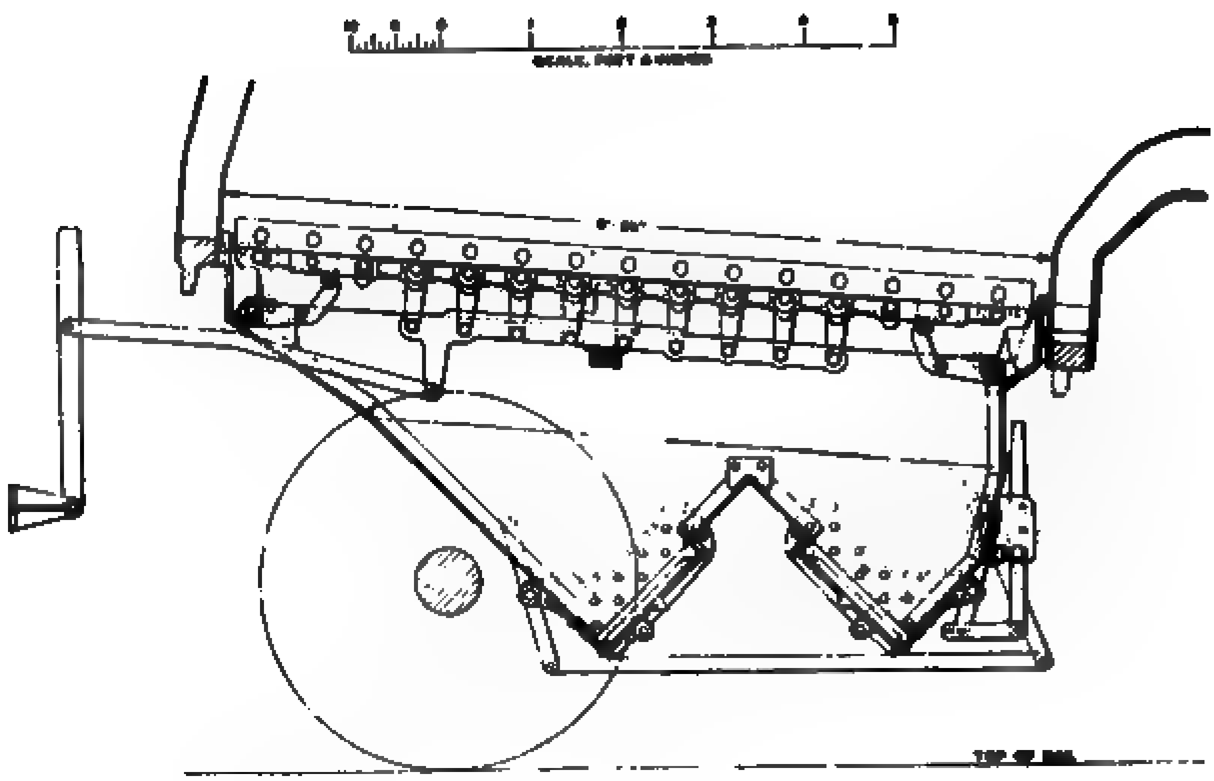


Fig. 5.

GRATE AND ASHPAN.

There is a drop grate at each end of the firebox. The remaining portion of the grate can be shaken in two separate sections. The ashpan has hinged openings.

Fig. 6.
SMOKEBOX AND SUPERHEATER.
The smokebox is arranged for self-cleaning.

Fig. 7.

CYLINDERS.

The live steam passages are outside of the cylinder saddle. The exhaust passages have few bends and these are of long radius.

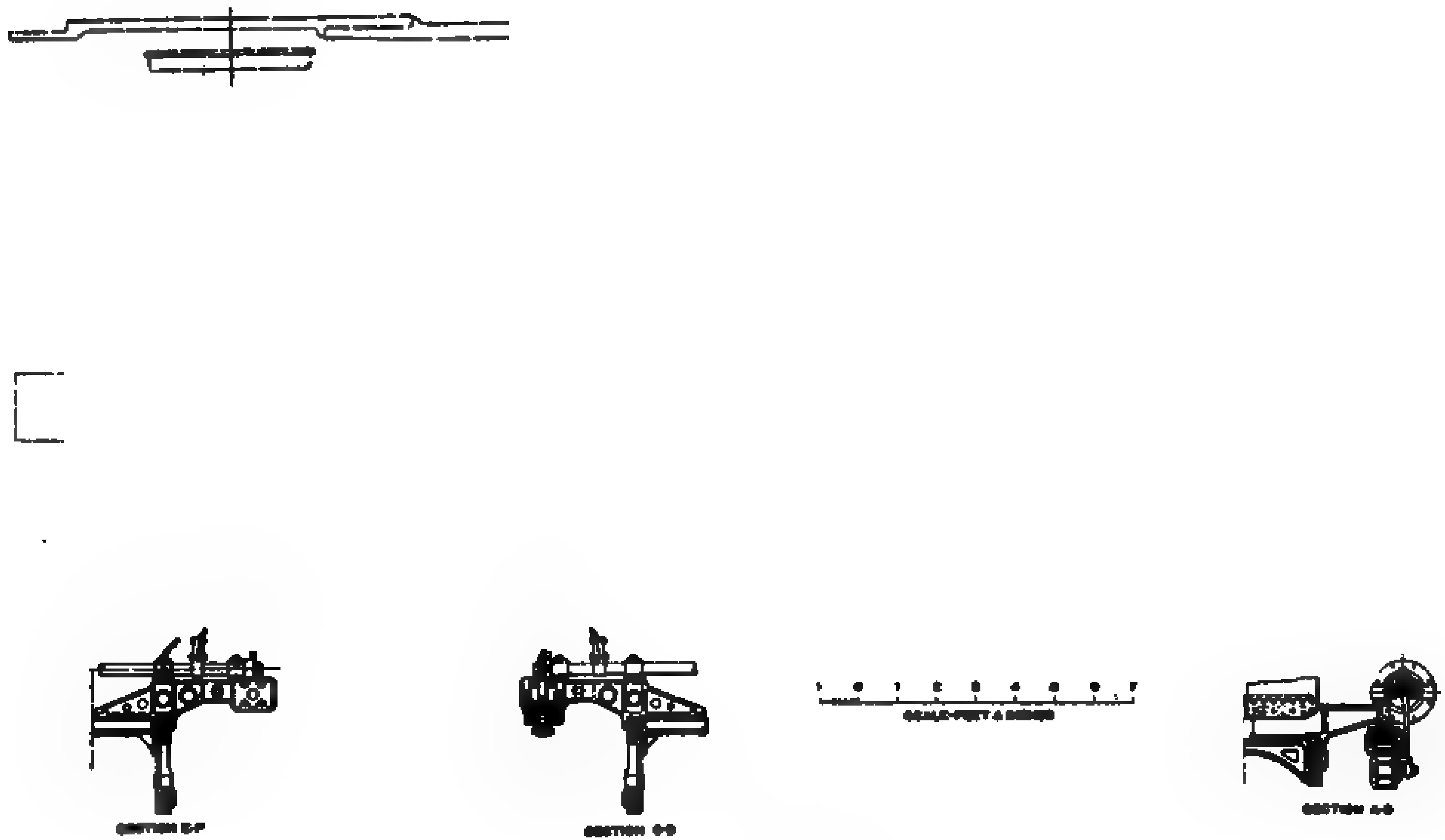


Fig. 8.

VALVE GEAR.

The valve gear is of the Walschaerts type and has been much reduced in weight by a redesign of the former gear.

has a 2¼-in. hole drilled through its whole length and it is then swedged down to the form shown in the drawing. The rod is of the extension type and the material is heat-treated steel. The crosshead has also been much reduced in weight. It is of the three-bar guide type. The small crosshead on the extension of the piston rod is cylindrical and is arranged so that it has four bearing surfaces which may be utilized in turn, these surfaces coming into position by removing the crosshead and replacing it after

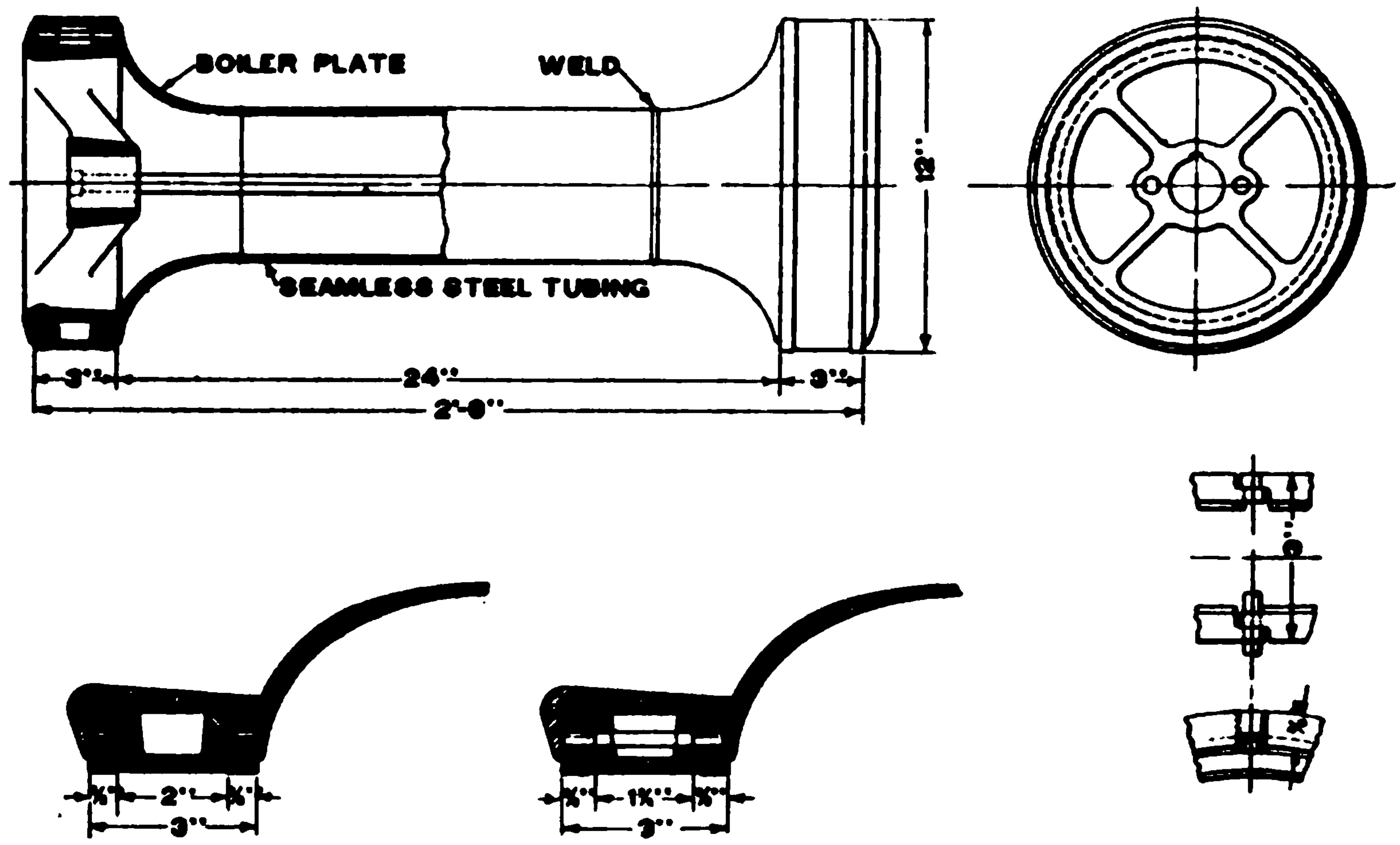


Fig. 9.
PISTON VALVE.

making a quarter turn. The piston is a steel casting with cast-iron rings, the rings are joined by phosphor bronze segments. The piston nut is secured by a thin washer, the edges of which are turned up against the side of the nut. The piston, piston rod and key complete weigh 402½ lb.

Equalization.

15. A novel system of equalization has been adopted for these E6s locomotives. It has been customary to equalize the trailer truck and the two driving axles together, making the front truck separate. In this new arrangement the front four-wheel truck is equalized with the front driving axle and the trailing truck with the rear driving axle. The equalization scheme being shown in Fig. 11. The grouping of the axles into two equalization units by including the front truck, gives greater flexibility and ensures full loading on the front truck at all times.

16. The total weight of the locomotive has been somewhat increased by the change in the boiler and cylinders, and it now weighs a total of

240,000 lb. with 133,100 lb. on the drivers. While the maximum weight on a pair of drivers is now 67,500 lb., the dynamic augment or the increased pressure on the rail due to the unbalanced revolving weights at 70 m.p.h is less than 30 per cent of the static weight on the drivers, or no greater than that with many locomotives having from 10,000 to 12,000 lb. less weight per axle but with heavy reciprocating parts. The great care in the design

Fig. 10.

EXHAUST NOZZLE TIP.

The nozzle is circular and the area is equivalent to that of a 6-inch circle. The partial bridges are four in number and they are wedge-shape in section. This nozzle tip is shown in the photograph, Fig. 21.

of these reciprocating parts has made possible a locomotive of this type which appears to be more powerful than locomotives of the Pacific type, while it has less destructive action upon the track.

Changes in Locomotive without Change in Classification.

17. The fact that Bulletin 21 described tests of a locomotive of the E6s class, while this bulletin refers to a locomotive of the same class which

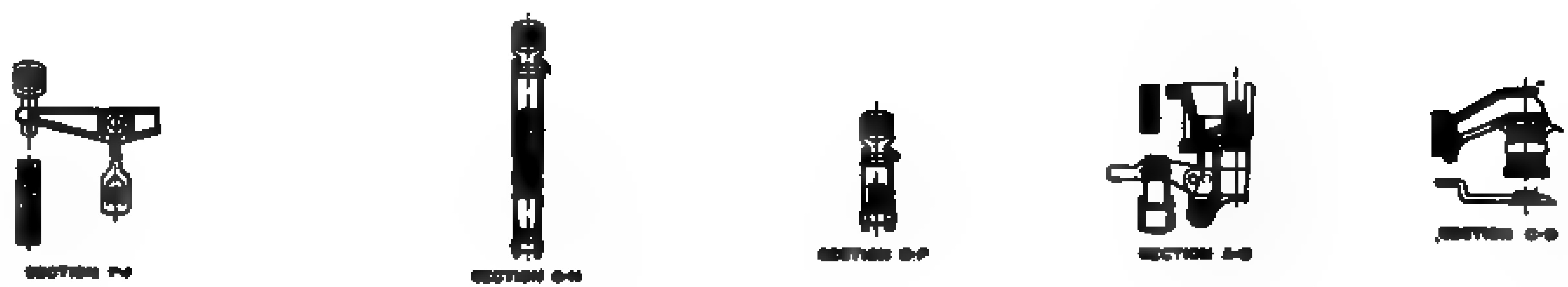


Fig. 11.

EQUALIZATION AND SPRING RIGGING.

The engine truck and first pair of drivers are connected by an equalizer. At the rear, the trailer truck frame forms the equalizer.

differs from the former in important particulars, may lead to confusion. The facts in regard to the changes in the locomotives are as follows: In 1910 a locomotive of the E6 class was built. In 1912 this locomotive had a superheater added and its classification changed to E6s; one more locomotive of the E6s class was built at this time and one class E6sa, differing from the others in having a special valve and valve gear. There were then two E6s and one E6sa locomotives. These locomotives had tubes 13 ft. 8⅝ in. long and cylinders 22 by 26 in.

18. In 1913, before June 1, the three locomotives were rebuilt with new cylinders 23½ by 26 in. and with other changes, but with no change in tube length. After June 1, 1913, a large number of locomotives of the E6s class with 15 ft. tubes were built and one of these latter, No. 51, is the subject of this bulletin.

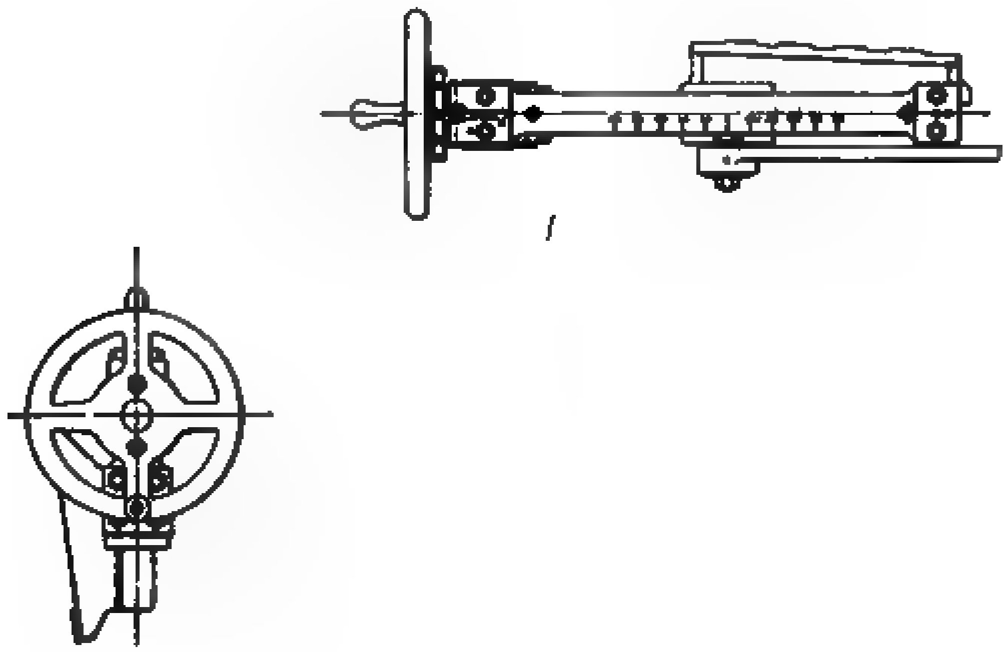


Fig. 12.
REVERSING GEAR.
The reversing gear is of the screw type and is marked with the approximate cut-off.

19. The E6 and E6sa classes no longer exist, and all locomotives of the E6s class now have tubes 15 ft. in length except three, in which they are the 13 ft. 8⅝ in. There are now no locomotives like the 89 and 5075, the tests of which are recorded in Bulletin 21.

COAL.

20. The coal used in the tests of No. 51 was the same as was used with locomotive No. 89, a bituminous coal from Westmoreland county, mined by the Penn Gas Coal Company of Irwin, Pennsylvania.

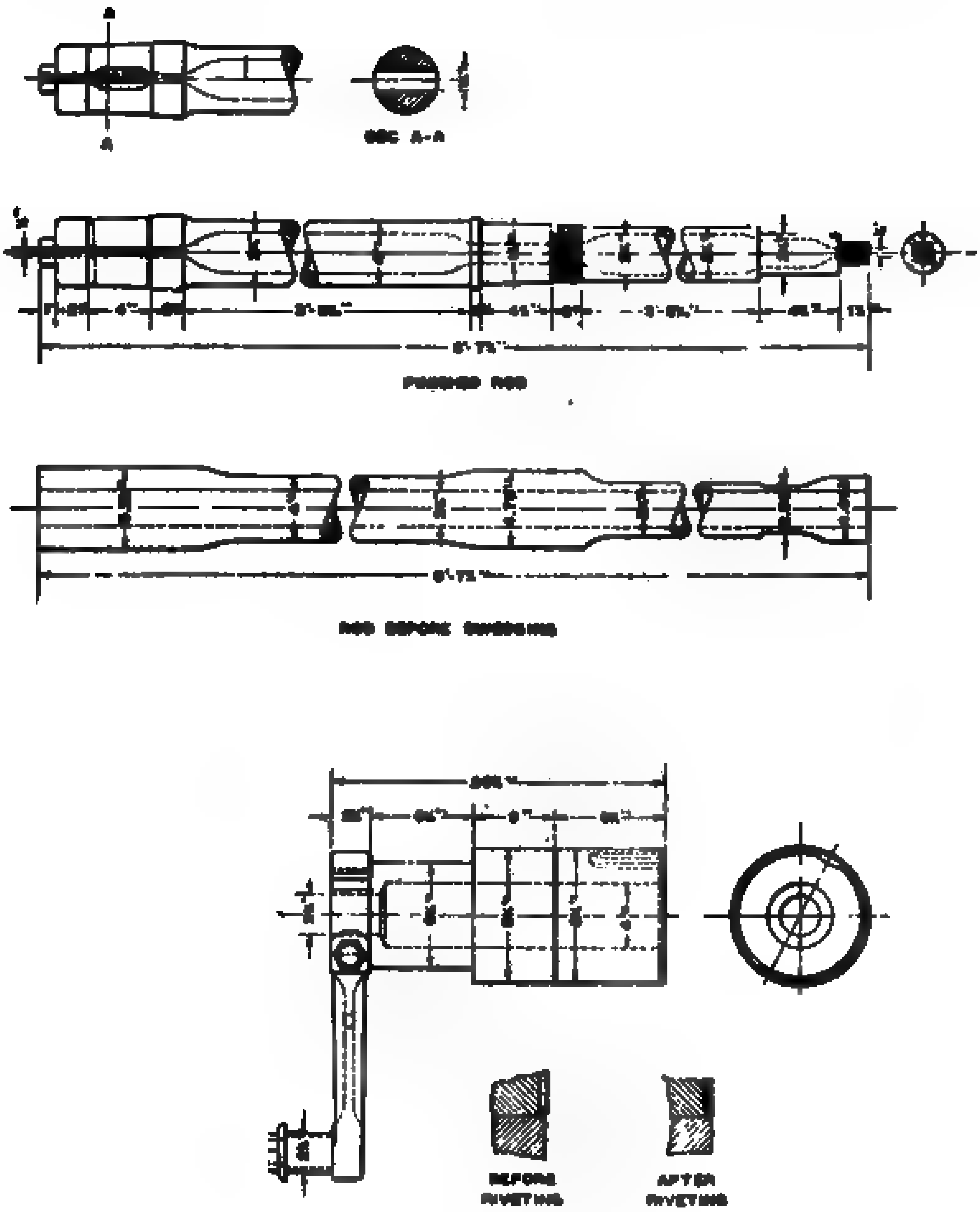


Fig. 13.

PISTON ROD AND MAIN CRANK PIN.

The piston rod is hollow. It is first drilled and then pressed into form in a forging press. The crank pins are hollow of heat-treated steel.

21. A representative sample of this coal when analyzed shows the following:

PROXIMATE ANALYSIS.

Fixed carbon, per cent	58.45
Volatile matter, per cent	33.65
Moisture, per cent	1.54
Ash, per cent	6.36
Total	100.00
Sulphur separately determined, per cent	1.62
B. t. u. per pound of coal, dry	14,470
B. t. u. per pound of coal, combustible	14,513

ULTIMATE ANALYSIS.

Carbon, per cent	79.19
Hydrogen, per cent	5.08
Nitrogen, per cent	1.53
Sulphur, per cent	1.62
Ash, per cent	6.36
Oxygen by difference, per cent	6.22
Total	100.00

THE TESTS.

22. The conditions of the thirty tests with locomotive No. 51 are shown in the following table:

Revolutions per Minute.	Miles per Hour.	Nominal Cut-off in Per Cent of Stroke.								
		15	20	25	30	35	38	40	45	50
120	28.1	1		1		1			2	
160	37.5	1		1		1			1	1
200	47.0	1		1		1			1	1
240	56.4	1		1		1			1	
280	65.8	1		1		1			1	
320	75.0	1		1		1				
360	84.4	1		1	1	1				

FULL THROTTLE TESTS, LOCOMOTIVE NO. 51, E6s CLASS.

They correspond closely with those made with locomotive No. 89 and described in Bulletin 21. No partial throttle tests were made with locomotive No. 51.

BOILER PERFORMANCE.

23. Many of the new parts on this locomotive are beyond the range of the investigations which can be undertaken on the testing plant, and their desirability or otherwise can be developed only by long trial in road service, but the change in the boiler arrangement by an increase in tube length should show effects easily traced, and the comparison of boiler results of the old and the new locomotives which we will make, seems to be on a fair basis, on account of the single change in the boiler.

Temperatures and Pressures.

24. Tables I and II show the range of steam pressure and temperature resulting from the operation of locomotive No. 51 during these tests. The boiler pressure, Table I, excepting in one instance, did not fall below 202 lb. The maximum pressure drop between boiler and branch pipe was 14.8 lb. at the maximum steam flow, as compared with 12.0 lb. for locomotive No. 89. The difference in drop is no doubt due to the longer steam passage and the larger volume of steam in the case of the 51.

25. The pressure in the exhaust passage ranged between 2.5 and 12.7 lb. The temperatures, corresponding with the pressures in Table I, are given in Table II and the highest steam temperature was 635.7°. The superheat in the branch pipe ranged between 137° F., and 251.3° F., while in the exhaust passage the superheat reached 60.8°. The highest superheat obtained from locomotive No. 89 was 238.8°, or a little less than that reached by No. 51.

Combustion, Draft and Temperature.

26. Table III, arranged according to the rate of equivalent evaporation from minimum to maximum, includes the drafts in inches of water measured in front and back of diaphragm, in firebox and ashpan, also the temperatures in firebox, smokebox and branch pipe in degrees Fahr., and the coal fired in pounds per hour per square foot of grate.

M. P. 479—A

LOCOMOTIVE:
TYPE 4-4-2
CLASS E6s No. 51

PENNSYLVANIA RAILROAD COMPANY
PHILADELPHIA, BALTIMORE & WASHINGTON RAILROAD COMPANY
NORTHERN CENTRAL RAILWAY COMPANY
WEST JERSEY & SEASHORE RAILROAD COMPANY
TEST DEPARTMENT

SHEET NO. P1501 Bulletin No. 27

Tests of a Class E6s Locomotive. ALTOONA, PA. 8-24-1914

STEAM PRESSURE.

Test No.	Test Designation	Duration of Test, Minutes	Steam Pressure by Gage in Boiler 217	Superheater Return Bend No. 1	Superheater Return Bend No. 2	Branch Pipe 220	Exhaust Passage
3854	120-15-F	120	205.9	200.7	201.4	201.5	2.5
3852	120-25-F	120	206.0	199.5	200.6	201.5	3.3
3847	120-35-F	120	205.9	198.3	199.7	199.7	4.6
3853	120-45-F	60	206.0	198.9	199.0	198.3	6.0
3851	120-45-F	60	205.7	197.7	199.3	197.4	3.1
3855	160-15-F	120	206.0	201.1	200.3	201.6	2.7
3833	160-25-F	90	205.0	201.1	200.6	201.9	3.5
3835	160-35-F	120	206.0	199.7	200.3	199.8	5.5
3850	160-45-F	60	205.9	196.9	198.9	196.3	5.9
3849	160-50-F	60	204.2	195.2	196.2	193.7	9.5
3836	200-15-F	120	206.0	201.8	202.4	202.1	2.7
3837	200-25-F	120	206.0	200.6	201.9	200.6	4.2
3807	200-35-F	60	204.6	200.1	198.1	197.6	5.7
3809	200-45-F	60	206.0	200.3	200.1	197.0	6.6
3848	200-50-F	60	204.9	195.1	196.3	190.1	12.7
3832	240-15-F	120	206.0	201.8	202.7	202.8	5.5
3844	240-25-F	90	206.0	199.1	201.2	199.8	3.8
3831	240-35-F	60	206.0	201.0	200.9	199.6	6.6
3810	240-45-F	60	202.6	195.0	194.9	191.6	11.7
3845	280-15-F	90	206.0	201.0	203.0	202.0	3.0
3808	280-25-F	90	204.0	200.2	198.7	198.4	4.9
3842	280-35-F	60	205.6	198.4	200.0	195.4	5.9
3811	280-40-F	60	202.4	195.7	194.4	191.9	10.5
3846	320-15-F	60	206.0	200.7	202.6	201.9	3.1
3834	320-25-F	60	206.0	200.0	201.7	199.9	5.9
3838	320-35-F	60	206.0	198.7	200.1	195.0	11.4
3841	360-15-F	30	206.0	201.3	203.0	202.3	3.0
3840	360-25-F	30	206.0	200.1	201.3	198.9	4.5
3839	360-30-F	30	206.0	198.8	200.3	196.3	8.1
3843	360-35-F	30	195.4	187.9	189.4	185.0	8.3

SHEET NO. P1501

Table I.

STEAM PRESSURES.

The boiler pressure was observed at the back head of the boiler. Pressures were measured in two of the return bends of the superheater or at the middle point of the steam passage through the superheater.

M. P. 470—A

LOCOMOTIVE:
TYPE 4-4-2
CLASS E6s No. 51

PENNSYLVANIA RAILROAD COMPANY

PHILADELPHIA, BALTIMORE & WASHINGTON RAILROAD COMPANY
NORTHERN CENTRAL RAILWAY COMPANY
WEST JERSEY & SEASHORE RAILROAD COMPANY

TEST DEPARTMENT

SHEET No. P1502

Bulletin No. 27

Tests of a Class E6s Locomotive.

ALTOONA, PA. 8-24-1914

STEAM TEMPERATURES.

Test No.	Test Designation	Duration of Test Minutes	Temperature: Boiler	Temperature: Branch Pipe	Temperature: Superheat in Branch Pipe	Temperature: Exhaust Passage	Temperature: Superheat in Exhaust Passage
3054	120-15-F	120	389.9	525.2	137.0	218.6	0.59
3052	120-25-F	120	389.9	540.0	151.8	222.5	2.14
3047	120-35-F	120	389.9	560.0	172.5	252.9	8.51
3053	120-45-F	60	389.9	578.9	192.0	240.6	12.47
3051	120-45-F	60	389.8	556.6	170.0	241.1	21.25
3055	160-15-F	120	389.9	551.5	143.2	219.4	0.77
3053	160-25-F	90	389.6	540.7	152.3	224.4	3.14
3035	160-35-F	120	390.0	571.8	184.2	236.6	8.52
3050	160-45-F	60	389.9	572.6	186.5	245.1	17.24
3049	160-50-F	60	389.2	592.7	207.6	265.3	28.42
3036	200-15-F	120	390.0	538.6	150.1	220.0	1.06
3037	200-25-F	120	390.0	552.6	164.7	229.8	6.42
3007	200-35-F	60	389.4	613.4	226.7	249.7	21.98
3009	200-45-F	60	389.9	652.0	245.6	282.6	55.01
3048	200-50-F	60	389.5	588.6	204.2	271.7	27.76
3032	240-15-F	120	389.9	534.3	145.6	220.3	6.50
3044	240-25-F	90	390.0	566.4	178.8	231.4	9.15
3031	240-35-F	60	389.9	599.1	201.6	244.9	15.18
3010	240-45-F	60	388.6	630.9	244.7	302.3	60.83
3045	280-15-F	90	390.0	547.8	159.4	223.4	3.61
3009	280-25-F	90	389.1	604.0	217.0	229.6	4.54
3042	280-35-F	60	389.8	601.4	215.6	256.0	28.05
3011	280-40-F	60	388.6	635.7	251.3	296.4	56.08
3046	320-15-F	60	390.0	544.0	155.6	225.4	3.19
3034	320-25-F	60	389.9	581.4	193.8	232.0	4.00
3038	320-35-F	60	390.0	601.7	216.0	270.9	29.67
3041	360-15-F	30	389.9	549.4	160.8	222.6	2.95
3040	360-25-F	30	389.9	585.1	197.9	235.7	11.62
3039	360-30-F	30	389.9	596.5	210.3	251.0	17.42
3043	360-35-F	30	385.8	611.4	229.9	235.4	51.22

SHEET No. P1502

Table II.

STEAM TEMPERATURES.

The boiler temperature is that corresponding to the steam pressure, and was taken from a steam table. The temperatures in branch pipe and exhaust passage were observed by means of a mercury thermometer in an oil well.

M. P. 479-A

8813 1-26 18
8 x 10½

LOCOMOTIVE:
TYPE 4-4-2
CLASS E6s No. 51

SHEET No. P1503

PENNSYLVANIA RAILROAD COMPANY

PHILADELPHIA, BALTIMORE & WASHINGTON RAILROAD COMPANY
NORTHERN CENTRAL RAILWAY COMPANY
WEST JERSEY & SEASHORE RAILROAD COMPANY
TEST DEPARTMENT

Bulletin No. 27

Tests of a Class E6s Locomotive. ALTOONA, PA. 8-24-1914

COMBUSTION, DRAFT AND TEMPERATURE.

Test No.	Test Designa-tion	Dura-tion of Test, Mins.	Draft in Inches of Water: In Front of Diaph-ragm	Draft: In Back of Diaph-ragm	Draft: In Fire box	Draft: In Ash pan	Temperature, Degrees Fahr.: In Fire box	Temperature: In Smoke box	Temperature: of Steam in Branch Pipe	Coal as Fired per sq.ft.of Grate, lbs. Per Hour
			222	223	224	225	212	207	210	
3854	120-15-F	120	2.0	1.1	0.5	0.09	1950	436	525.2	26.88
3855	160-15-F	120	2.4	1.3	0.7	0.13	2076	453	531.5	29.69
3856	200-15-F	120	2.5	1.5	0.7	0.13	2066	457	538.6	34.46
3852	120-25-F	120	3.0	1.7	0.8	0.16	2086	464	540.0	33.71
3832	240-15-F	120	2.9	1.8	0.8	0.11	2110	475	534.3	37.59
3845	280-15-F	90	3.2	2.0	0.8	0.11	2120	502	547.8	39.65
3833	160-25-F	90	4.1	2.2	1.0	0.14	2017	480	540.7	43.96
3846	320-15-F	60	4.0	2.6	1.1	0.10	2290	496	544.0	39.58
3841	360-15-F	30	4.0	2.5	1.1	0.15	2320	504	549.4	40.04
3837	200-25-F	120	4.7	2.8	1.1	0.20	2098	493	552.6	49.85
3847	120-35-F	120	5.1	2.9	1.1	0.20	2266	525	540.0	51.17
3844	240-25-F	90	5.9	3.7	1.4	0.17	2240	526	566.4	54.07
3808	280-25-F	90	6.0	3.6	1.8	0.22	2133	583	604.0	57.54
3853	120-45-F	60	6.7	3.5	1.3	0.25	2285	547	578.9	60.38
3835	160-35-F	120	6.8	3.9	1.5	0.25	2388	530	571.8	63.96
3851	120-45-F	60	7.0	3.8	1.5	0.30	2295	549	556.6	65.04
3834	320-25-F	60	7.2	4.0	1.6	0.25	2395	540	581.4	61.31
3807	200-35-F	60	7.5	4.4	1.9	0.26	2440	610	613.4	74.88
3840	360-25-F	30	7.9	4.8	1.7	0.25	2305	582	585.1	71.69
3850	160.45-F	60	9.3	5.4	2.1	0.40	2400	561	572.6	84.28
3831	240-35-F	60	10.2	5.8	2.[illegible]	0.27	2485	565	589.1	85.85
3839	360-30-F	30	11.0	7.1	2.9	0.24	2560	615	596.5	111.59
3809	200-45-F	60	10.7	5.7	2.3	0.25	2480	660	632.0	111.13
3842	280-35-F	60	11.2	6.8	2.7	0.36	2365	593	601.4	97.24
3811	280-40-F	60	13.0	7.9	3.0	0.23	2415	663	635.7	122.72
3849	160-50-F	60	12.6	7.6	2.6	0.26	2430	632	592.7	110.88
3843	360-35-F	30	13.8	8.7	2.9	0.20	2510	629	611.4	139.05
3810	240-45-F	60	12.5	7.0	2.7	0.32	2490	651	630.9	129.95
3838	320-35-F	60	12.9	7.4	2.9	0.33	2355	609	601.7	108.87
3848	200-50-F	60	15.1	9.4	3.5	0.40	2555	609	588.6	150.56

SHEET No. P1503

Table III.

COMBUSTION DRAFT AND TEMPERATURE.

In front of the diaphragm the draft ranges between 2 and 15 inches of water. In the firebox it is less than one-quarter of what it is in the smokebox.

M. P. 679—A

LOCOMOTIVE:
TYPE 4-4-2
CLASS E6s No. 51

PENNSYLVANIA RAILROAD COMPANY
PHILADELPHIA, BALTIMORE & WASHINGTON RAILROAD COMPANY
NORTHERN CENTRAL RAILWAY COMPANY
WEST JERSEY & SEASHORE RAILROAD COMPANY
TEST DEPARTMENT

Bulletin No. 27

SHEET No. P1504

Tests of a Class E6s Locomotive. ALTOONA, PA. 8-24-1914

COMBUSTION, GENERAL CONDITIONS.

Test No.	Test Designation	Duration of Test Mins.	Average Pressure in Lbs. per Sq. in. Boiler	Average Pressure in Lbs. per Sq. in. Atmospheric	Temperature Degrees, Fahr. Testing Plant	Temperature Degrees, Fahr. Feed Water	Dry Coal Fired Per Hour, Lbs. per Sq. ft. of Grate	Total Water Evap. lbs. per Sq. ft. of Heating Surface	Ratio 339 to 342
			217	221	206	211	339	342	
3854	120-15-F	120	205.9	14.06	77	70.2	26.47	4.07	6.50
3855	160-15-F	120	206.0	14.05	79	73.3	29.23	4.55	6.42
3836	200-15-F	120	206.0	14.15	78	66.5	33.64	5.24	6.42
3852	120-25-F	120	206.0	14.02	81	72.6	33.20	5.47	6.07
3832	240-15-F	120	206.0	14.07	68	66.1	36.71	5.58	6.58
3845	280-15-F	90	206.0	14.13	84	67.1	39.02	5.93	6.58
3833	160-25-F	90	205.0	14.12	69	68.3	42.93	6.28	6.83
3846	320-15-F	60	206.0	14.17	82	67.3	38.97	6.35	6.14
3841	360-15-F	30	206.0	14.09	79	67.0	39.11	6.62	5.91
3837	200-25-F	120	206.0	14.15	74	68.7	48.68	7.21	6.75
3847	120-35-F	120	205.9	14.11	78	67.8	50.40	7.24	6.96
3844	240-25-F	90	206.0	14.15	75	67.0	53.25	7.88	6.75
3808	280-25-F	90	204.0	14.05	79	65.8	56.66	8.07	7.02
3855	120-45-F	60	206.0	14.05	75	70.0	59.46	8.45	7.03
3835	160-35-F	120	206.0	14.17	71	66.3	62.45	8.66	7.21
3851	120-45-F	60	205.7	14.05	78	69.0	64.04	8.81	7.27
3834	320-25-F	60	206.0	14.10	74	67.0	59.87	8.76	6.83
3807	200-35-F	60	204.6	14.20	65	62.5	73.78	9.18	8.03
3840	360-25-F	30	206.0	14.10	74	66.0	70.01	9.73	7.19
3850	160-45-F	60	205.9	14.05	78	68.7	82.91	10.35	8.01
3831	240-35-F	60	206.0	14.06	69	69.3	83.81	10.83	7.73
3839	360-30-F	30	206.0	14.10	71	66.0	108.94	11.17	9.75
3809	200-45-F	60	206.0	14.01	71	64.0	109.41	11.15	9.81
3842	280-35-F	60	205.6	14.09	81	67.0	94.93	11.51	8.24
3811	280-40-F	60	202.4	14.16	61	63.0	120.83	11.51	10.49
3849	160-50-F	60	204.2	14.10	79	68.0	109.11	11.76	9.28
3843	360-35-F	30	193.4	14.15	75	66.5	135.76	12.05	11.28
3810	240-45-F	60	202.6	13.95	78	63.0	127.94	12.10	10.57
3838	320-35-F	60	206.0	14.14	84	66.7	106.33	12.34	8.61
3848	200-50-F	60	204.9	14.09	90	67.5	148.25	13.10	11.31

SHEET No. P1504

Table IV.

COMBUSTION—GENERAL CONDITIONS.

27. The draft in front of diaphragm increased to 15.1 in. of water when the rate of firing reached 150.56 lb. of coal per sq. ft. of grate per hour. The draft back of diaphragm was 9.4 in. In the firebox it was 3.5 in. and 0.40 in. in the ashpan.

28. The vacuum in the ashpan is somewhat higher than that obtained with locomotive No. 89. One instance of this is at a speed of 200 r.p.m. and cut-off of 50 per cent. The combustion rate for No. 51 was 148.25 lb. of coal per hour per sq. ft. of grate with an ashpan vacuum of 0.40 in., while the 89 burned 142.17 lb. of coal with a vacuum of 0.15 in. The air inlet area in the ashpan of locomotive No. 89 was 8.1 sq. ft., or equal to 14.6 per cent of the grate area, and that of the 51, 7.85 sq. ft., or 15 per cent of the grate area.

29. The smokebox temperatures ranged between 436° F. and 663° F. A slight improvement is noticed in this respect compared with the smokebox temperatures of the 89. The longer boiler tubes of No. 51 apparently absorb more heat.

30. Draft readings taken in the front end at right side, left side, top and bottom, at points approximately eight in. in front of the tube sheet, indicated a very even vacuum within the front end, showing that the front end arrangement is well designed for this locomotive.

31. The following table is presented to show the draft readings taken at the four points above mentioned, at different rates of evaporation:

Pounds of Water Evaporated Per Hour.	Draft in Smokebox, Inches of Water.			
	Right Side	Left Side	Top	Bottom
15 492	1.5	1.5	1.4	1.1
20 200	2.1	2.1	2.1	2.2
24 645	3.2	3.3	3.1	3.1
30 008	4.3	4.2	4.0	3.4
35 238	5.8	5.7	5.6	
40 063	8.1	7.8	7.7	8.5
44 628	9.6	9.3	9.3	10.1

32. It is thus seen that the superheater damper does not materially affect or hinder the draft, and that the damper opening is sufficient to balance or equalize the vacuum on all sides.

33. After a few tests had been made, it was found that the smokebox was not cleaning properly and cinders were accumulating, and to overcome this, two changes were made in the front end arrangement. The pocket or depression in the diaphragm plate around the nozzle was made of a solid plate instead of netting, and an extension to the diaphragm plate at

the forward end was applied as shown in Fig. 6. After these changes no further trouble was found with the action of the front end.

Combustion Rate.

34. The dry coal fired per hour, Table V, ranged between 1477 and 8271 lb., and the rate of combustion per sq. ft. of grate per hour was from 26.47 lb. to 148.25 lb., while, based on a square foot of heating surface, it ranged between 0.434 and 2.429 lb.

35. The heat absorbed by the superheater ranged from 6 to 9.5 per cent, or less than 10 per cent of that absorbed by the water heating surface.

36. The combustion rate increased regularly with the draft up to a rate of firing of approximately 148 lb. of dry coal per hour per sq. ft. of grate when the maximum draft obtained was 15 in. of water. Fig. 14 indicates that had the rate of firing been materially increased above this amount there would not have been sufficient draft to promote good combustion. At the maximum rate of combustion, 20 per cent of the draft was expended in drawing air through the fuel bed, 40 per cent in moving the gases through the flues and 37 per cent in drawing the gases from the back to the front of diaphragm. With locomotive No. 89 it required approximately 18.3 per cent from ashpan to firebox, 29.5 per cent from firebox to back of diaphragm and 51 per cent from back to front of diaphragm. Hence, lengthening the tubes has had its effect upon the required draft. The greater expenditure of draft is noted for firebox and tubes, as well as the less amount required between front and back of diaphragm for the 51, indicating an improvement in the front end. A comparison between the percentages of draft expended in the fireboxes of the two locomotives indicates that a greater air opening in the ashpan of No. 51 would prove beneficial to its performance.

37. As shown in Table IX, the calorific value of the dry fuel was quite uniform throughout the tests, and ranged between 14,160 and 14,375 B.t.u. At the high rates of firing, the heat in the coal lost by the presence of CO increased to 10.4 per cent. The smoke observations show low numbers.

Evaporation Rate.

38. The evaporation, Table VI, ranged from 13,865 to 44,628 lb. of water per hour. The maximum draft produced was 15.1 in. of water, and Fig. 15 shows that a further increase in draft would have produced a very little increase in the evaporation rate under the prevailing conditions.

39. In Fig. 16, showing the firebox and smokebox temperatures, we find that while the firebox temperatures are higher for the 51 with the longer tubes, the smokebox temperatures are lower for this locomotive. The increased heating surface in the tubes appears to have the expected effect of absorbing a larger amount of heat and delivering the waste gases at lower temperatures than with the shorter tube boiler.

40. Locomotive No. 89 developed a maximum evaporation of 38,846 lb.

M. P. 470—A

PENNSYLVANIA RAILROAD COMPANY
PHILADELPHIA, BALTIMORE & WASHINGTON RAILROAD COMPANY
NORTHERN CENTRAL RAILWAY COMPANY
WEST JERSEY & SEASHORE RAILROAD COMPANY
TEST DEPARTMENT

LOCOMOTIVE:
TYPE 4-4-2
CLASS E6s No. 51

SHEET No. P1505

Bulletin No. 27

Tests of a Class E6s Locomotive. ALTOONA, PA., 8-24-1914

RATE OF COMBUSTION AND HEAT TRANSFER.

Test No.	Test Designation	Duration of Test, Mins.	Total Dry Coal Fired	Dry Coal Fired per Hour	Rate of Combustion: Dry Coal Fired Per Sq.ft.of Grate Per Hour	Rate of Combustion: Dry Coal Per Sq.Ft of Heating Surface Per Hour	Heat Transfered Across Water Heating Surface B.t.u. Per Minute	Heat Transfered Across Superheating Sur.B.T.U. Per Minute
			235	338	339			
3854	120-15-F	120	2954	1477	26.47	0.434	268360	16251
3855	160-15-F	120	3262	1631	29.23	0.479	299049	20935
3836	200-15-F	120	3754	1877	33.64	0.551	346375	24671
3852	120-25-F	120	3704	1852	33.20	0.544	360144	26756
3832	240-15-F	120	4096	2048	36.71	0.601	369197	25702
3845	280-15-F	90	3266	2177	39.02	0.639	392017	30163
3833	160-25-F	90	3593	2395	42.93	0.703	414636	30881
3846	320-15-F	60	2174	2174	38.97	0.638	419810	31590
3841	360-15-F	30	1091	2182	39.11	0.641	437781	32117
3837	200-25-F	120	5431	2716	48.68	0.797	475981	37554
3847	120-35-F	120	5625	2812	50.40	0.826	477990	38937
3844	240-25-F	90	4456	2971	53.25	0.872	521173	44256
3808	280-25-F	90	4741	3161	56.66	0.928	534822	53196
3853	120-45-F	60	3317	3317	59.46	0.974	557399	49985
3835	160-35-F	120	6968	3484	62.45	1.023	572931	50347
3851	120-45-F	60	3573	3573	64.04	1.049	581406	47546
3834	320-25-F	60	3340	3340	59.87	0.981	579249	52780
3807	200-35-F	60	4116	4116	73.78	1.209	608985	63680
3840	360-25-F	30	1953	3906	70.01	1.147	643757	58902
3850	160-45-F	60	4626	4626	82.91	1.358	684504	59282
3831	240-35-F	60	4676	4576	83.81	1.373	714185	66894
3839	360-30-F	30	3039	6078	108.94	1.785	738818	69206
3809	200-45-F	60	6104	6104	109.41	1.792	738801	82925
3842	280-35-F	60	5296	5296	94.93	1.555	761047	76864
3811	280-40-F	60	6741	6741	120.83	1.979	763517	88144
3849	160-50-F	60	6087	6087	109.11	1.787	776787	75713
3843	360-35-F	30	3787	7574	135.76	2.224	795322	84183
3810	240-45-F	60	7138	7138	127.94	2.096	802363	90891
3838	320-35-F	60	5932	5932	106.33	1.742	815975	81833
3848	200-50-F	60	8271	8271	148.25	2.429	865712	82513

SHEET No. P1505

Table V.

RATE OF COMBUSTION AND HEAT TRANSFER.

Coal was fired at a maximum rate of 8271 pounds per hour, or at a rate of 148 pounds per square foot of grate.

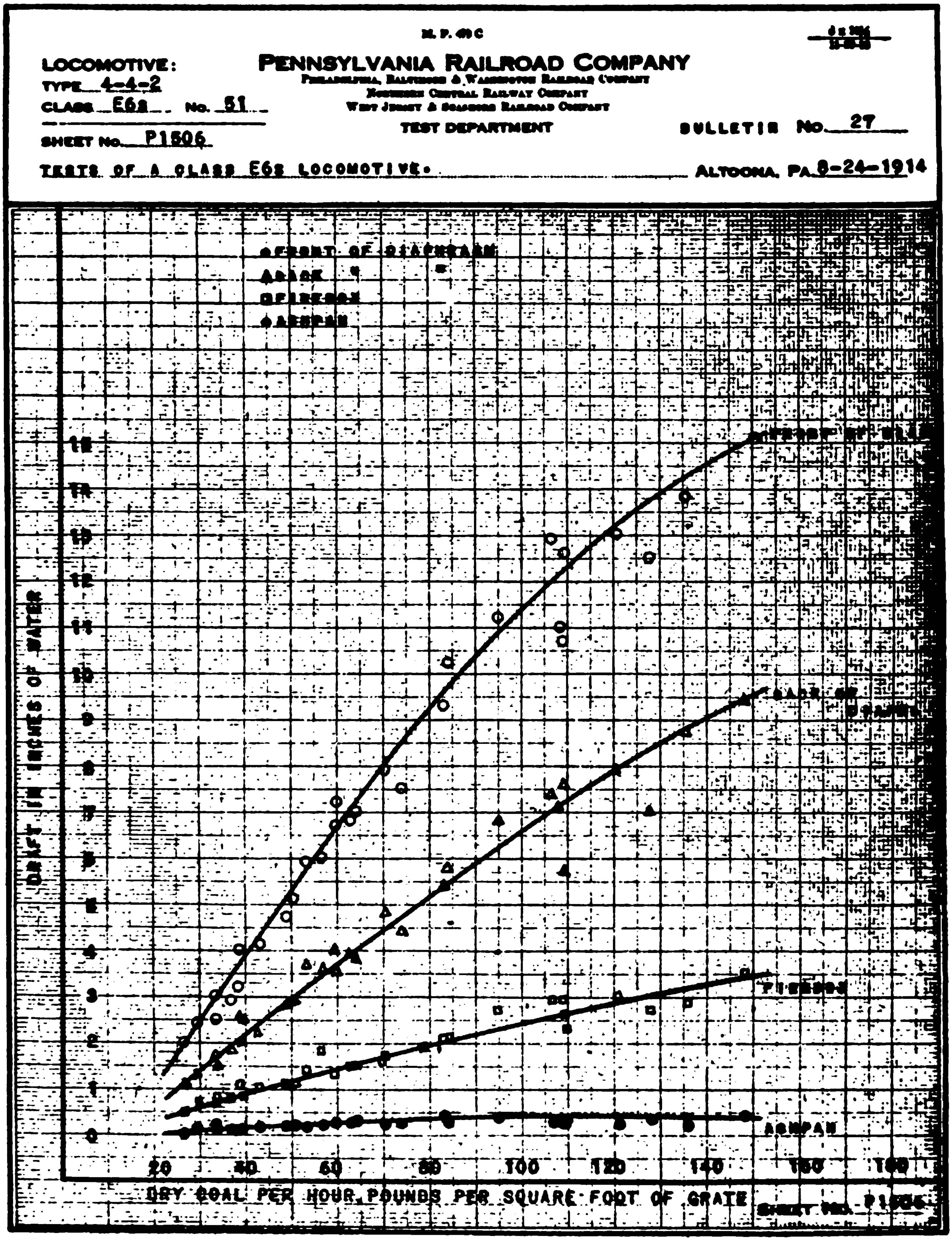


Fig. 14.

DRAFT AND RATE OF COMBUSTION.

At a draft of 15 inch in front of diaphragm, a point is approached where there would be no increase in draft even if much more coal were to be fired.

M. P. 678—A

LOCOMOTIVE:
TYPE 4-4-2
CLASS E6s No. 51

PENNSYLVANIA RAILROAD COMPANY

PHILADELPHIA, BALTIMORE & WASHINGTON RAILROAD COMPANY
NORTHERN CENTRAL RAILWAY COMPANY
WEST JERSEY & SEASHORE RAILROAD COMPANY

TEST DEPARTMENT

SHEET No. P1507 Bulletin No. 27

Tests of a Class E6s Locomotive. ALTOONA, PA. 8-24-1914

EVAPORATIVE PERFORMANCE.

Test No.	Test Designation	Water and Steam: Total Pounds of Water Evaporated	Water and Steam: Pounds of Water Evaporated Per Hour	Evaporative Performance: Total Water Divided by Total Coal	Evaporative Performance: Equiv. Evap. Per Pound of Dry Coal	Superheat in Branch Pipe, Degrees F.	Equiv. Evap., Pounds Per Hour.	Efficiency of Boiler, Per cent
		264	340		347	230	344	350
3834	120-15-F	27730	13865	9.39	12.00	136.98	17724	82.84
3835	160-15-F	30984	15492	9.50	12.13	143.24	19789	93.13
3836	200-15-F	35678	17839	9.50	12.25	150.10	22966	82.73
3832	120-25-F	37290	18645	10.01	12.92	151.79	23925	88.54
3833	240-15-F	38015	19008	9.28	11.94	145.55	24450	80.64
3845	280-15-F	30300	20200	9.28	12.00	159.35	26125	82.24
3853	160-25-F	32063	21389	8.93	11.80	152.29	27547	77.66
3846	320-15-F	21636	21636	9.96	12.85	156.57	27926	88.06
3841	360-15-F	11278	22556	10.34	13.38	160.84	29194	90.36
3837	200-25-F	49120	24560	9.04	11.69	164.70	31756	78.95
3847	120-35-F	49290	24645	8.77	11.38	172.48	31994	77.99
3844	240-25-F	40280	26853	9.04	11.77	178.82	34981	80.66
3865	280-25-F	41228	27485	8.70	11.55	217.02	36440	77.83
3855	120-45-F	28793	28793	8.68	11.35	191.96	37581	77.65
3858	160-35-F	59004	29502	8.47	11.07	184.21	38547	74.76
3851	120-45-F	30008	30008	8.40	10.88	170.02	38872	74.58
3854	320-25-F	29845	29845	8.94	11.70	193.80	39079	79.02
3807	200-35-F	31260	31260	7.58	10.12	226.68	41654	69.14
3840	360-25-F	16570	33140	8.48	11.14	197.90	43505	75.23
3850	160-45-F	35258	35258	7.62	9.94	186.46	45969	68.12
3831	240-35-F	36870	36870	7.88	10.34	201.64	48355	69.83
3839	360-30-F	19017	38034	6.26	8.24	210.34	50186	55.78
3809	200-45-F	37968	37968	6.22	8.33	245.60	50843	56.23
3842	280-35-F	39213	39213	7.40	9.78	215.60	51816	64.05
3811	280-40-F	39215	39213	5.82	7.81	251.38	52659	52.72
3849	160-50-F	40065	40065	6.58	8.66	207.58	52711	59.35
3843	360-35-F	20493	40986	5.41	7.18	229.92	54384	48.49
3810	240-45-F	41808	41808	5.77	7.74	246.68	55251	52.25
3838	320-35-F	42051	42051	7.09	9.37	216.04	55561	63.28
3848	200-50-F	44628	44628	5.40	7.09	204.15	58641	48.59

SHEET No. P1507

Table VI.

EVAPORATIVE PERFORMANCE.

The maximum evaporation was at the rate of 44,628 pounds per hour. At this rate of evaporation the superheat was 204 degrees.

Fig. 16.

DRAFT AND RATE OF EVAPORATION.

An increase in draft above 15 inches in front of diaphragm would produce but little increase in evaporation, and the limit of evaporation is nearly reached at 10 pounds per square foot of heating surface.

Fig. 16.

FIREBOX AND SMOKEBOX TEMPERATURE.

The firebox temperature for the 81 is considerably higher than for the 80, while the 81 shows the lowest smokebox temperature.

M. P. 479-A

LOCOMOTIVE:
TYPE 4-4-2
CLASS E6s No. 51

PENNSYLVANIA RAILROAD COMPANY
PHILADELPHIA, BALTIMORE & WASHINGTON RAILROAD COMPANY
NORTHERN CENTRAL RAILWAY COMPANY
WEST JERSEY & SEASHORE RAILROAD COMPANY

TEST DEPARTMENT

Bulletin No. 27

SHEET No. P1510

Tests of a Class E6s Locomotive. ALTOONA, PA. 8-24-1914

BOILER POWER.

Test No.	Test Designation	Duration of Test, Mins.	Equiv. Evap., Pounds Per Sq.Ft. of Grate Surface Per Hour	Equiv. Evap., Pounds Per Sq.Ft. of Heating Surface Per Hour	Boiler Horsepower Total	Boiler Horsepower Per Sq.ft. of Heating Surface	Boiler Horsepower Per Sq.Ft. of Grate Surface	Efficiency of Boiler. Per cent
				345	349			350
3854	120-15-F	120	317.69	5.20	513.7	0.150	9.21	82.24
3855	160-15-F	120	354.71	5.81	573.6	0.169	10.28	83.13
3836	200-15-F	120	412.01	6.75	666.3	0.194	11.94	82.73
3852	120-25-F	120	428.84	7.03	693.5	0.203	12.43	88.54
3832	240-15-F	120	438.25	7.18	708.7	0.208	12.70	80.64
3845	280-15-F	90	468.27	7.67	757.2	0.222	13.57	82.24
3833	160-25-F	90	493.76	8.09	798.5	0.234	14.33	77.66
3846	320-15-F	60	500.56	8.20	809.4	0.237	14.51	88.06
3841	360-15-F	30	523.28	8.57	846.2	0.248	15.17	90.36
3837	200-25-F	120	569.21	9.32	920.5	0.270	16.50	78.95
3847	120-35-F	120	573.47	9.39	927.4	0.272	16.62	77.99
3844	240-25-F	90	627.01	10.27	1013.9	0.298	18.17	80.66
3808	280-25-F	90	653.16	10.70	1056.2	0.310	18.93	77.85
3853	120-45-F	60	673.62	11.03	1089.3	0.320	19.52	77.65
3835	160-35-F	120	690.93	11.32	1117.3	0.328	20.03	74.76
3851	120-45-F	60	696.76	11.41	1126.7	0.330	20.18	74.58
3834	320-25-F	60	700.47	11.47	1132.7	0.332	20.30	79.02
3807	200-35-F	60	746.62	12.23	1207.4	0.354	21.64	69.14
3840	360-25-F	30	779.76	12.77	1261.0	0.370	22.60	75.23
3850	160-45-F	60	824.31	13.50	1333.0	0.392	23.89	68.12
3831	240-35-F	60	866.73	14.20	1401.6	0.412	25.30	69.85
3839	360-30-F	30	899.55	14.74	1454.7	0.427	26.07	55.78
3809	200-45-F	60	911.33	14.93	1473.7	0.433	26.42	56.23
3842	280-35-F	60	928.77	15.21	1501.9	0.441	26.90	66.05
3811	280-40-F	60	943.88	15.46	1526.3	0.448	27.36	52.72
3849	160-50-F	60	944.83	15.48	1527.9	0.448	27.39	59.35
3843	360-35-F	30	974.80	15.97	1576.3	0.463	28.25	48.49
3810	240-45-F	60	989.98	16.22	1600.9	0.470	28.70	52.25
3838	320-35-F	60	995.89	16.31	1610.5	0.473	28.87	63.28
3848	200-50-F	60	1051.08	17.22	1699.7	0.498	30.47	48.59

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Table VII.

BOILER POWER.

The range of boiler horse-power is between 500 and 1700, or at the maximum rate of 0.498 per square foot of heating surface, or 30.47 per square foot of grate.

M. P. 470—A

LOCOMOTIVE:
TYPE 4-4-2
CLASS E6s No. 51

PENNSYLVANIA RAILROAD COMPANY
PHILADELPHIA, BALTIMORE & WASHINGTON RAILROAD COMPANY
NORTHERN CENTRAL RAILWAY COMPANY
WEST JERSEY & SEASHORE RAILROAD COMPANY
TEST DEPARTMENT

Bulletin No. 27

SHEET NO. P1511

Tests of a Class E6s Locomotive. ALTOONA, PA. 8-24-1914

EVAPORATION RATE, BOILER AND SUPERHEATER.

Test No.	Test Designation	Water Evaporated, Pounds Per Hour.	Equivalent Evaporation from and at 212° F. Lbs. Per Hour: Boiler Excluding Superheater	Superheater Alone	Boiler Including Superheater	Per Sq. Ft. of Heating Surface: Boiler Excluding Superheater	Superheater Alone	Boiler Including Superheater	Ratio of Superheater to Boiler Evap. Per Sq. ft. of Heat. Sur.
		340			344			345	
3854	120-15-F	13865	16596	1128	17724	6.40	1.39	5.20	0.217
3855	160-15-F	15492	18497	1392	19789	7.13	1.72	5.81	0.241
3836	200-15-F	17839	21781	1205	22986	8.39	1.49	6.75	0.178
3852	120-25-F	18645	22262	1763	23925	8.58	2.17	7.03	0.253
3832	240-15-F	19008	22829	1621	24450	8.80	2.00	7.18	0.227
3845	280-15-F	20200	24220	1905	26125	9.33	2.35	7.67	0.252
3833	160-25-F	21389	25598	1949	27547	9.86	2.40	8.09	0.243
3846	320-15-F	21636	25942	1984	27926	10.00	2.45	8.20	0.245
3841	360-15-F	22556	27067	2227	29194	10.43	2.62	8.57	0.251
3837	200-25-F	24560	29423	2333	31756	11.34	2.88	9.32	0.254
3847	120-35-F	24645	29549	2445	31994	11.39	3.02	9.39	0.265
3844	240-25-F	26853	32224	2757	34981	12.42	3.40	10.27	0.274
3808	280-25-F	27485	33064	3376	36440	12.74	4.16	10.70	0.327
3853	120-45-F	28793	34465	3116	37581	13.28	3.84	11.03	0.289
3835	160-35-F	29502	35502	3045	38547	13.68	3.76	11.32	0.275
3851	120-45-F	30008	35950	2922	38872	13.85	3.60	11.41	0.260
3834	320-25-F	29845	35814	3265	39079	13.80	4.03	11.47	0.292
3807	200-35-F	31260	37653	4001	41654	14.51	4.94	12.23	0.340
3840	360-25-F	33140	39801	3702	43503	15.34	4.57	12.77	0.294
3850	160-45-F	35238	42321	3668	45989	16.31	4.52	13.50	0.277
3831	240-35-F	36870	44133	4222	48355	17.01	5.21	14.20	0.306
3839	360-30-F	38034	45679	4507	50186	17.60	5.56	14.74	0.316
3809	200-45-F	37968	45679	5164	50843	17.60	6.37	14.93	0.362
3842	280-35-F	39213	47056	4760	51816	18.13	5.87	15.21	0.324
3811	280-40-F	39213	47209	5450	52659	18.19	6.72	15.46	0.369
3849	160-50-F	40063	47995	4716	52711	18.49	5.82	15.48	0.315
3843	360-35-F	40986	49142	5242	54384	18.94	6.47	15.97	0.342
3810	240-45-F	41208	49610	5621	55231	19.12	6.93	16.22	0.362
3838	320-35-F	42031	50437	5124	55561	19.44	6.32	16.31	0.325
3848	200-50-F	44628	53509	5132	58641	20.62	6.33	17.22	0.307

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Table VIII.

EVAPORATION RATE—BOILER AND SUPERHEATER.

In this table the equivalent evaporation is shown for the boiler and superheater separately.

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LOCOMOTIVE.
TYPE 4-4-2
CLASS E6s No. 51

PENNSYLVANIA RAILROAD COMPANY

PHILADELPHIA, BALTIMORE & WASHINGTON RAILROAD COMPANY
NORTHERN CENTRAL RAILWAY COMPANY
WEST JERSEY & SEASHORE RAILROAD COMPANY

TEST DEPARTMENT

Bulletin No. 27

SHEET NO. P1512

Tests of a Class E6s Locomotive.

ALTOONA, PA. 9-24-1914

SMOKEBOX GASES.

Test No.	Test Designation	Duration of Test, Mins.	Analysis of Smokebox Gases: Percent Oxygen O	Percent Carbon Monoxide CO	Percent Carbon Dioxide CO_2	Percent Nitrogen N	Calorific Value of Dry Coal B.t.u. per Pound	Percent of Heat in Coal Lost by Presence of C O	Temperature of Smokebox	Smoke Percent Ringlemann Scale
			253	254	255	256	248		207	
3854	120-15-F	120	4.8	0.2	13.1	81.9	14160	0.85	436	10
3855	160-15-F	120	4.4	0.3	13.3	82.0	14160	1.27	453	10
3836	200-15-F	120	4.0	0.2	13.7	82.1	14369	0.80	457	6
3852	120-25-F	120	4.4	0.2	13.2	82.2	14160	0.85	464	8
3832	240-15-F	120	4.3	0.3	13.5	81.9	14369	1.22	475	8
3845	280-15-F	90	3.9	0.2	14.0	81.9	14160	0.80	502	8
3833	160-25-F	90	3.8	0.7	13.6	82.0	14369	2.74	480	12
3846	320-15-F	60	2.7	0.5	14.5	82.3	14160	1.89	496	10
3841	360-15-F	30	3.5	0.0	14.7	81.8	14369		504	10
3837	200-25-F	120	2.9	0.3	14.4	82.4	14369	1.14	493	12
3847	120-35-F	120	3.6	0.3	13.9	82.2	14160	1.20	525	8
3844	240-25-F	90	2.4	0.2	15.1	82.3	14160	0.74	526	6
3808	280-25-F	90	3.4	0.2	13.8	82.6	14375	0.80	583	18
3853	120-45-F	60	3.1	0.3	13.3	83.2	14160	1.25	547	10
3835	160-35-F	120	3.4	0.5	13.7	82.5	14369	1.97	530	8
3851	120-45-F	60	2.5	0.3	14.6	82.6	14160	1.14	549	8
3834	320-25-F	60	3.4	0.2	13.8	82.6	14369	0.80	540	12
3807	200-35-F	60	4.3	1.5	12.5	81.6	14204	6.06	610	22
3840	360-25-F	30	2.1	0.3	14.8	82.8	14369	1.11	582	12
3850	160-45-F	60	1.9	0.6	14.6	82.9	14160	2.24	561	12
3831	240-35-F	60	1.3	1.5	15.1	82.1	14369	5.05	565	16
3839	360-30-F	30	1.0	3.1	13.5	82.4	14369	10.44	615	32
3809	200-45-F	60	4.3	1.1	12.3	82.3	14375	4.59	660	42
3842	280-35-F	60	1.7	0.2	15.2	82.9	14369	0.73	593	14
3811	280-40-F	60	5.4	2.1	11.1	81.4	14375	8.89	663	46
3849	160-50-F	60	0.4	2.5	14.0	83.1	14160	8.60	632	34
3843	360-35-F	30	0.8	2.1	14.3	82.8	14369	7.16	629	34
3810	240-45-F	60	4.8	0.9	11.9	82.4	14375	3.93	651	38
3838	320-35-F	60	1.4	1.0	14.9	82.7	14369	3.52	609	18
3848	200-50-F	60	0.7	1.4	14.5	83.4	14160	5.00	609	46

SHEET NO. P1512

Table IX.

SMOKEBOX GASES.

The calorific value of the coal is considerably above 14,000 B.t.u. per pound. The temperature of the smokebox is below 700 degrees, while with the E6s, 89 it was as much as 770 degrees.

Fig. 17.

COAL FIRED AND WATER EVAPORATED.

With an increase in heating surface of 10 per cent. there is an increase in evaporation of 15 per cent. The maximum evaporation with the 51 was 44,800 pounds per hour.

Fig. 18.

BOILER EFFICIENCY AND RATE OF EVAPORATION.

The boiler efficiency has been very much improved by the increase in tube length.

per hour in the tests, and as shown in Fig. 17 this was exceeded by the 51 which evaporated 44,600 lb. per hour. The increase in evaporation is 15 per cent, while the new heating surface is but 10 per cent greater than in the 89.

41. The boiler efficiency has been much improved as is illustrated by Fig. 18. In the case of the 89, a line through the points is straight, while for the 51 a curve only can be drawn. On this account a more exact statement of the difference in the efficiency can not be made.

42. The equivalent evaporation per pound of coal is about 9 per cent greater for the 51 than for the former 89, when a comparison is made at equal rates of combustion. This is shown in Fig. 19.

43. Referring to Fig. 22 where comparisons are made between the evaporations per pound of coal at all rates of evaporation per sq. ft. of heating surface, we find that the 51 again shows superior results up to the maximum rate. At the maximum rate of evaporation the two lines meet. The 89 evaporated water at a maximum rate of 16.86 and the 51 at a maximum of 17.22 lb. per sq. ft. of heating surface.

44. In Fig. 23 where the two curves of boiler efficiency are parallel, there is shown an efficiency for the 51 which is about 9 per cent better than that of the 89. The 51 burned a maximum of 148.25 lb. of coal per sq. ft. of grate, while the 89 burned 142.17.

Exhaust Nozzle.

45. The locomotive was first run with a circular exhaust nozzle having an opening 6.25 in. in diameter. An evaporation of 35,928 lb. per hour was obtained at a speed of 200 r.p.m. with a 45 per cent cut-off. A four projection or partially bridged nozzle was then substituted having a circular opening, the area of which was 30.95 sq. in., or the equivalent of a nozzle with a diameter of 6.276 in.

46. This type of nozzle is illustrated in Fig. 20. It is a circular cast-iron nozzle having four internal triangular projections, for the purpose of diffusing the jet. The projections, as shown, are cast in the nozzle. The nozzle is cast ready for use with the exception of the necessary drilling and tapping for studs and blower device. Test No. 3807 was made with this nozzle.

47. A projection or partially bridged nozzle, Figs. 10 and 21, with machined projections of steel held in place by small studs, was then applied and used for the remaining tests (3808 to 3855) and it appeared that this nozzle with the machined projections gave the better results.

48. A four projection nozzle with an opening having an area of 30.68 sq. in. or equivalent to a 6¼-in. diameter circular nozzle, gave the highest evaporation, 44,628 lb. per hour during a 200-50-F test. A similar nozzle with an area of 27.06 sq. in. produced a maximum evaporation of 42,420 lb. per hour at a speed of 240 r.p.m. with a cut-off of 45 per cent.

49. With locomotive No. 89 the tests were first undertaken with a

Fig. 19.

EQUIVALENT EVAPORATION PER POUND OF COAL.

The evaporation per pound of coal for the 51 is about 9.6 per cent. above that of the 58.

Fig. 20.—EXHAUST NOZZLE.

This nozzle has the partial bridges or projections cast in place. One of this form was used in Test 3807.

Fig. 21.—EXHAUST NOZZLE.

This nozzle has wedge-shaped steel projections or partial bridges. Practically all of the tests were made with this form of nozzle.

6½-in. diameter circular nozzle and an evaporation of 36,300 lb. of water per hour was obtained. In order to bring about a more complete filling of the stack, a 4¾ by 6½ in. rectangular nozzle was applied, which resulted in increasing the evaporation to 38,800 lb. per hour, with a draft of 12.9 in. of water.

SUPERHEAT.

50. The superheat ranged between 137.0° F. and 251.3° F., Table II. The maximum superheat showed an increase of 12.5° above that obtained from the short-tube boiler of the 89. As the tests of the two locomotives do not cover the same range of evaporation, Fig. 27, a comparison of the average superheat for the whole series of tests is not possible. The heat in B.t.u. transferred across one sq. ft. of superheating surface in the boiler was 112 for the 51 and 120 for the 89, at the maximum rates of evaporation, Table V. The advantage in heat absorption per sq. ft. of superheating surface is with the locomotive No. 89; the better absorption of the superheater of the 89 being due, no doubt, to the higher temperature of the gases passing through the tubes.

51. The ratio of the equivalent evaporation per sq. ft. of heating surface in the superheater to that in the boiler, Table VIII, ranged from 0.178 to 0.369 while that for the 89 ranged between 0.236 and 0.367.

TUBE LENGTH.

52. In Bulletin 21 in discussing the tube length of the former E6s boiler, the suggestion is made that an improvement would result from an increase in tube length to 15 ft. This lengthening of the boiler tubes on locomotive No. 51 by nearly 10 per cent has increased the evaporation rate 15 per cent. The difference in the temperature drop between firebox and smokebox of the two locomotives gradually incrased at like rates of firing in favor of the longer tube boiler up to 264° F. This was due to the higher firebox and lower smokebox temperatures given by the 51, indicated that more heat was taken up by the longer tube boiler. The boiler efficiency of this locomotive, based on the rate of combustion per sq. ft. of grate, shows an increase of 9 per cent above that obtained from the 89, and its equivalent evaporation per sq. ft. of heating surface reached 17.22 lb.

53. The results thus obtained prove that a ratio of tube length to internal diameter of 103 with 2-in. tubes is better than a ratio of 94. While it is true that the short tube boiler showed a greater activity of combustion for like drafts, yet there was hardly any difference in the rapidity of evaporation in the two boilers until a draft of 5 in. back of the diaphragm was reached, whereupon the shorter tube boiler showed a more rapid rate until its evaporation limit was reached.

Fig. 22.

EQUIVALENT EVAPORATION PER POUND OF DRY COAL.

The boiler of the 51 shows very good results at a rate of between 11 and 14 pounds evaporated per square feet of heating surface.

Fig. 23.

BOILER EFFICIENCY AND RATE OF COMBUSTION.

The boiler efficiency of the 51 is about 3 per cent. above that of the 50.

Ratios.

54. Lengthening the tubes in the E6s boiler has had the effect of changing a few of the ratios as follows:

	E6s-89	E6s-51
Total heating surface (fireside) to grate area..	55.94	61.23
Firebox heating surface to grate area........	4.61	4.17
Tube surface (fireside) to firebox heating surface....................................	8.43	10.15
Firebox volume to grate area...............	6.43	6.16

55. The effect has been to increase the boiler horse-power from 1509.7 to 1699.7 or 12.6 per cent in favor of the 51. There is not much difference in the boiler horse-power per sq. ft. of heating surface between the two boilers, but, per sq. ft. of grate surface, the maximum boiler horse-power exceeds that obtained from the 89 by 11.5 per cent or by an amount equal to the increase in heating surface and indicating that the grate area is sufficient on both of these boilers, and does not restrict the output of the boiler which is benefited by the added heating surface.

PERFORMANCE OF ENGINES.

Test Conditions.

56. The efficiency tests with the locomotive on the test plant were made at speeds ranging between 120 and 360 r.p.m., Table X. Expressed in miles per hour, these speeds were between 28.1 and 84.4 m.p.h. The nominal cut-offs were between 15 and 50 per cent of the stroke. The boiler pressure for the several tests was well maintained and the superheat in the branch pipe increased from 137.0 to 251.3° F., as the evaporation increased.

Indicator Diagrams.

57. Representative indicator diagrams are presented in Figs. 24, 25 and 26. Steam chest diagrams are also shown for the indicator diagrams which were taken from the left side of the locomotive. Fig. 24 shows a set of diagrams at full stroke and another set at a cut-off of 63 per cent. These four diagrams were obtained when running the locomotive for periods of about 5 minutes, hence they have no test number. The dia-

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LOCOMOTIVE: **PENNSYLVANIA RAILROAD COMPANY**

TYPE 4-4-2 PHILADELPHIA, BALTIMORE & WASHINGTON RAILROAD COMPANY

CLASS E6s No. 51 NORTHERN CENTRAL RAILWAY COMPANY

WEST JERSEY & SEASHORE RAILROAD COMPANY

TEST DEPARTMENT Bulletin No. 27

SHEET No. P1518

Tests of a Class E6s Locomotive. ALTOONA, PA. 8-24-1914

ENGINE TEST CONDITIONS.

Test No.	Test Designation	Duration of Test, Mins.	Revolutions Per Minute	Speed in Miles Per Hour	Cut-off in Per cent of Stroke	Steam Pressure: In Boiler Pounds Per Square Inch	Steam Pressure: In Branch Pipe, Lbs. Per Square Inch	Superheat in Branch Pipe Degrees Fahr.
			198	199	272	217	220	230
3854	120-15-F	120	120	28.1	16.8	205.9	201.5	137.0
3852	120-25-F	120	120	28.1	27.1	206.0	201.5	151.8
3847	120-35-F	120	120	28.1	38.1	205.9	199.7	172.5
3853	120-45-F	60	120	28.1	42.4	206.0	198.3	192.0
3851	120-45-F	60	120	28.1	43.4	205.7	197.4	170.0
3855	160-15-F	120	160	37.4	17.9	206.0	201.6	143.2
3833	160-25-F	90	160	37.5	25.3	205.0	201.9	152.3
3835	160-35-F	120	160	37.5	41.1	206.0	199.8	184.2
3850	160-45-F	60	160	37.5	44.5	205.9	196.3	186.5
3849	160-50-F	60	160	37.5	49.8	204.2	193.7	207.6
3836	200-15-F	120	200	46.9	20.1	206.0	202.1	150.1
3837	200-25-F	120	200	46.9	28.8	206.0	200.6	164.7
3807	200-35-F	60	200	47.0	37.7	204.6	197.6	226.7
3809	200-45-F	60	200	47.0	44.5	206.0	197.0	245.6
3848	200-50-F	60	200	46.9	52.0	204.9	190.1	204.2
3832	240-15-F	120	240	56.4	20.1	206.0	202.8	145.6
3844	240-25-F	90	240	56.3	29.6	206.0	199.8	178.8
3831	240-35-F	60	240	56.4	39.7	206.0	199.6	201.6
3810	240-45-F	60	240	56.4	47.7	202.6	191.6	246.7
3845	280-15-F	90	280	65.6	17.9	206.0	202.0	159.4
3808	280-25-F	90	280	65.8	24.8	204.0	198.4	217.0
3842	280-35-F	60	280	65.6	43.1	205.6	195.4	215.6
3811	280-40-F	60	280	65.8	45.2	202.4	191.9	251.3
3846	320-15-F	60	320	75.0	18.2	206.0	201.9	155.6
3834	320-25-F	60	320	75.0	30.2	206.0	199.9	193.8
3838	320-35-F	60	320	75.0	41.5	206.0	195.0	216.0
3841	360-15-F	30	360	84.4	19.0	206.0	202.3	160.8
3840	360-25-F	30	360	84.4	30.9	206.0	198.9	197.9
3839	360-30-F	30	360	84.4	34.9	206.0	196.3	210.3
3843	360-35-F	30	360	84.4	42.1	195.4	185.0	229.9

SHEET No. P1518

Table X.

ENGINE TEST CONDITIONS.

The speeds were between 28 and 84 m.p.h. with cut-offs from 16 to 52 per cent. In all of these tests practically full boiler pressure was maintained.

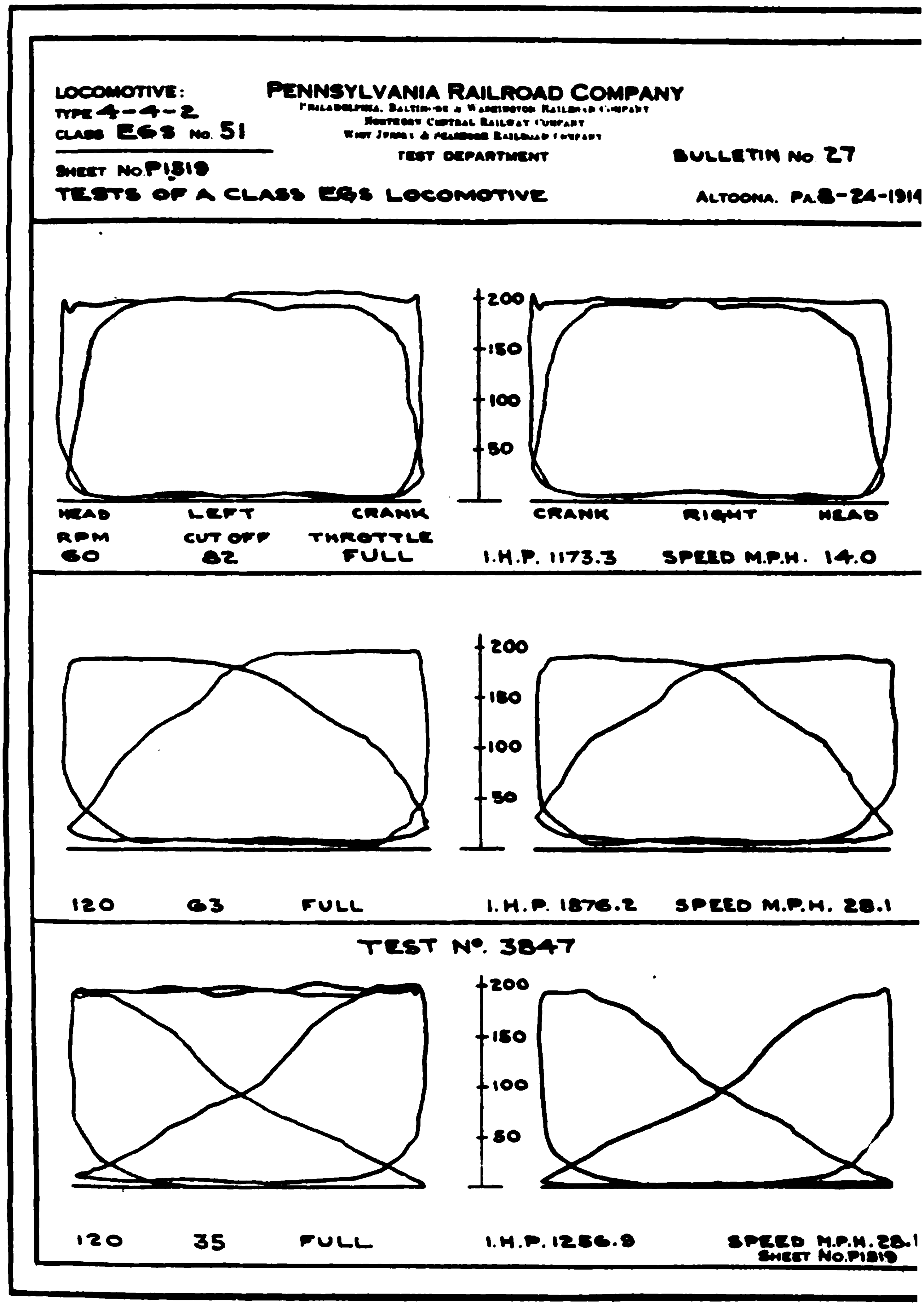


Fig. 24.

TYPICAL INDICATOR DIAGRAMS.

The diagrams for 60 r.p.m. and 82 per cent. cut-off were taken at the longest cut-off that could be obtained, or with the valve motion in full forward gear.

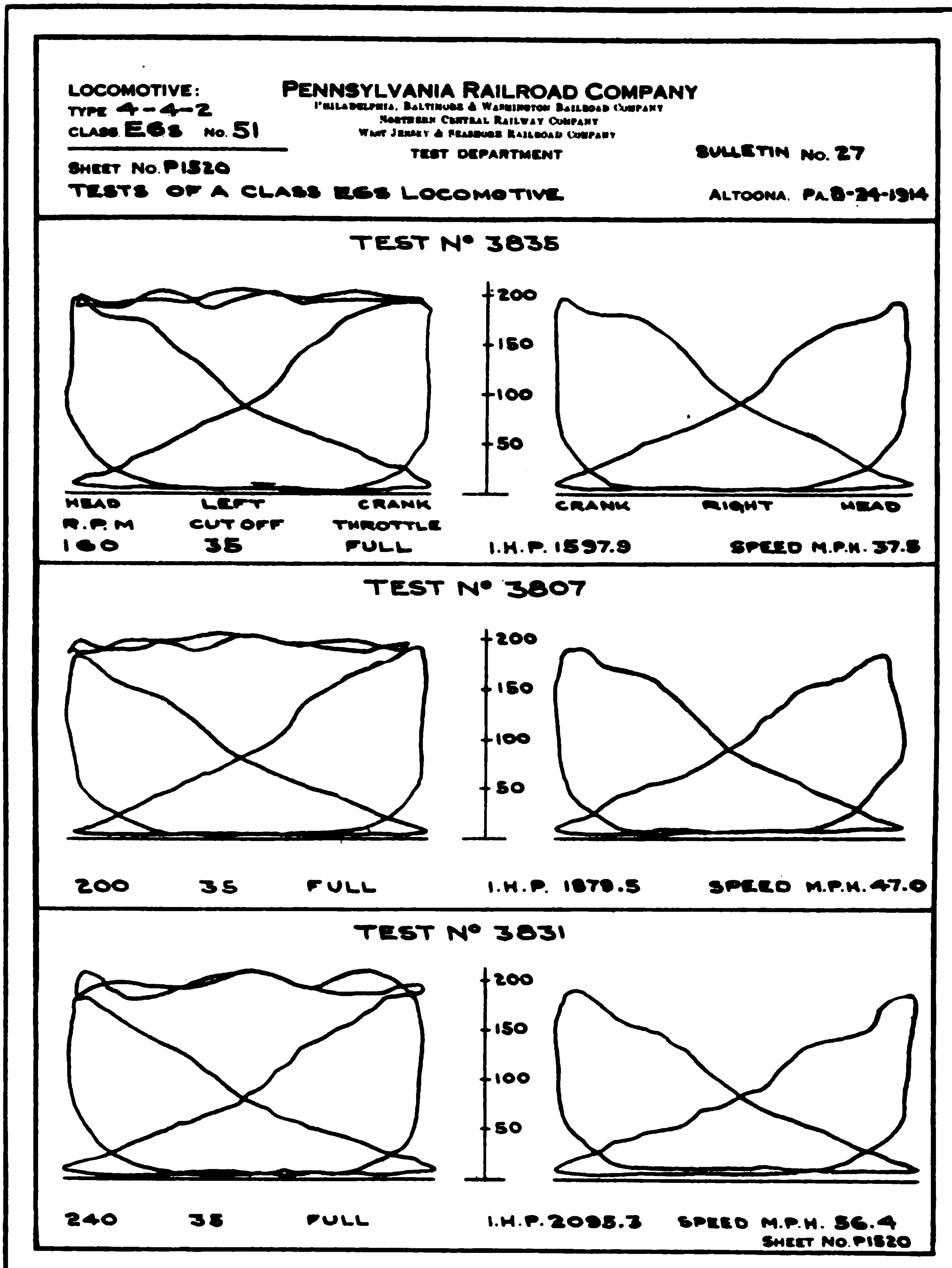


Fig. 25.

TYPICAL INDICATOR DIAGRAMS.

Speeds from 37.5 to 56.4 m.p.h.

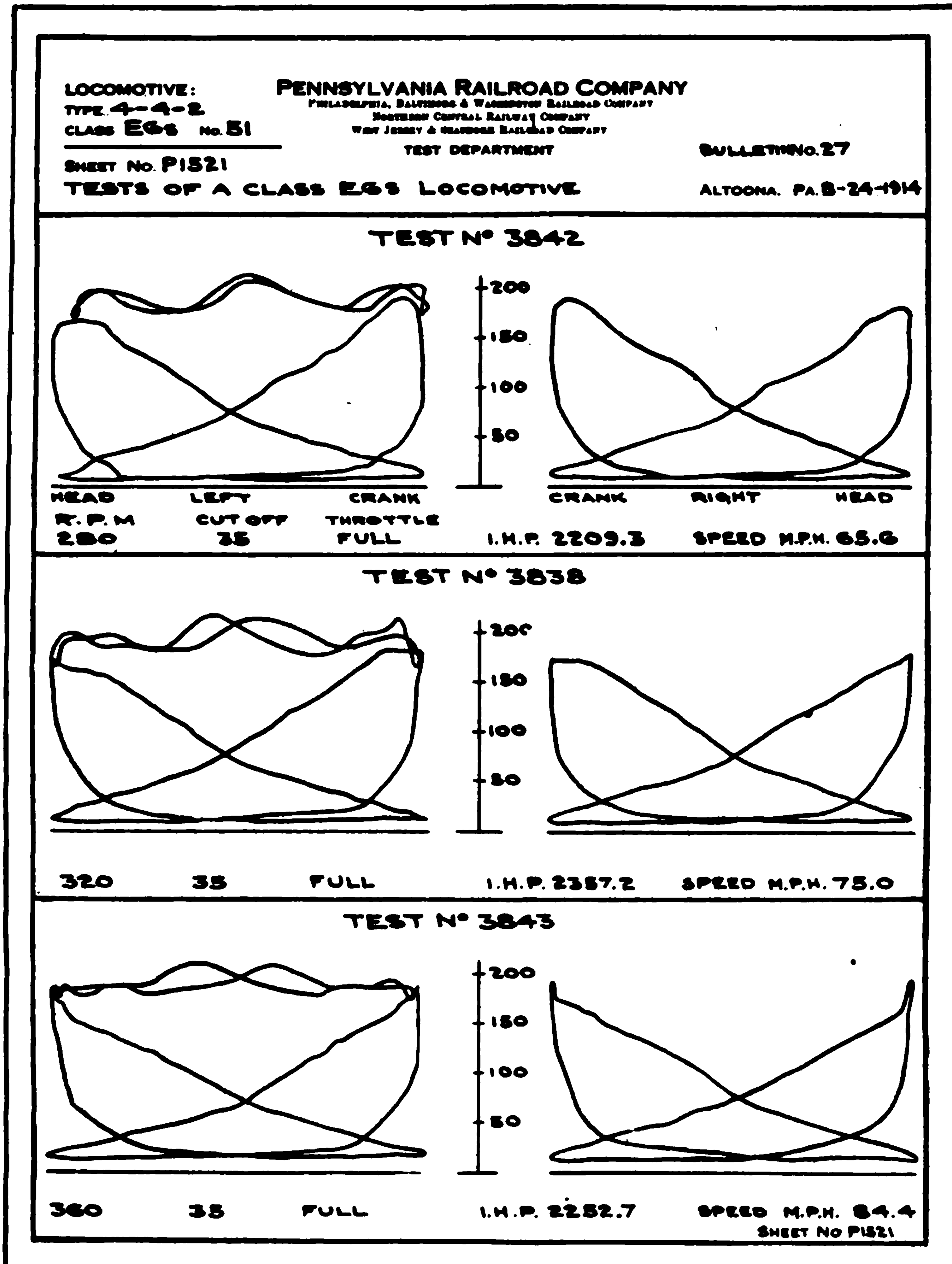


Fig. 26.

TYPICAL INDICATOR DIAGRAMS.

Speeds from 65.6 to 84.4 m.p.h.

M. P. 479—A

LOCOMOTIVE: TYPE 4-4-2 CLASS E6s No. 51

SHEET No. P1522

PENNSYLVANIA RAILROAD COMPANY

PHILADELPHIA, BALTIMORE & WASHINGTON RAILROAD COMPANY
NORTHERN CENTRAL RAILWAY COMPANY
WEST JERSEY & SEASHORE RAILROAD COMPANY

TEST DEPARTMENT

Bulletin No. 27

Tests of a Class E6s Locomotive. ALTOONA, PA. 8-24-1914

INDICATED HORSEPOWER.

Test No.	Test Designation	Duration of Test, Mins.	Speed in M.P.H.	Steam to Engs. Pounds Per Hr.	Mean Effective Pressure, Pounds Per Sq. In.	Indicated Horse power	Dry Coal Per Indicated Horsepower Hour, Lbs.	Superheated Steam Per Indicated Horsepower Hour, Pounds	B.t.u. in Steam Per Indicated Horsepower
			199	214		379	380	381	
3854	120-15-F	120	28.1	12322	46.43	620.3	2.38	19.86	24636
3855	160-15-F	120	37.4	15443	43.68	776.1	2.10	19.90	24668
3852	120-25-F	120	28.1	18611	70.02	933.2	1.98	19.94	24830
3836	200-15-F	120	46.9	17347	42.09	934.7	2.01	18.56	23207
3832	240-15-F	120	56.4	18627	37.96	1011.7	2.02	18.41	22980
3833	160-25-F	90	37.5	21389	57.82	1116.2	2.15	19.16	23946
3845	280-15-F	90	65.6	19980	37.75	1173.7	1.85	17.02	21360
3846	320-15-F	60	75.0	21451	35.03	1245.1	1.75	17.23	21582
3847	120-35-F	120.	28.1	24326	94.33	1266.9	2.24	19.35	24377
3841	360-15-F	30	84.4	21072	32.80	1311.1	1.66	16.07	20184
3837	200-25-F	120	46.9	24521	60.86	1351.4	2.01	18.15	22773
3851	120-45-F	60	28.1	29860	109.00	1452.5	2.46	20.56	25845
3853	120-45-F	60	28.1	28555	109.50	1459.1	2.27	19.57	24787
3844	240-25-F	90	56.3	26657	55.72	1484.6	2.00	17.96	22704
3835	160-35-F	120	37.5	29446	89.95	1597.6	2.18	18.43	23366
3808	280-25-F	90	65.8	26817	53.64	1667.4	1.90	16.08	20688
3834	320-25-F	60	75.0	29845	44.27	1750.9	1.91	17.05	21664
3850	160-45-F	60	37.5	35238	102.62	1823.3	2.54	19.33	24481
3807	200-35-F	60	47.0	30776	84.63	1879.5	2.19	16.37	21167
3840	360-25-F	30	84.4	32630	48.14	1924.2	2.03	16.96	21604
3849	160-50-F	60	37.5	39993	113.58	2018.0	3.02	19.82	25305
3831	240-35-F	60	56.4	36346	78.64	2095.3	2.23	17.35	22081
3809	200-45-F	60	47.0	37715	95.97	2131.0	2.86	17.70	23000
3839	360-30-F	30	84.4	36136	53.51	2138.9	2.84	16.89	21563
3842	280-35-F	60	65.6	39157	71.07	2209.3	2.40	17.72	22722
3843	360-35-F	30	84.4	40902	56.36	2252.7	3.36	18.16	23383
3810	240-45-F	60	56.4	41208	86.39	2302.1	3.10	17.90	23281
3848	200-50-F	60	46.9	44530	103.79	2304.8	3.59	19.32	24635
3811	280-40-F	60	65.8	39213	75.81	2356.7	2.86	16.64	21684
3838	320-35-F	60	75.0	41631	66.35	2357.2	2.52	17.66	22659

SHEET No. P1522

Table XI.

INDICATED HORSE-POWER.

The maximum indicated horse-power obtained was 2357.2 with a coal rate of 2.52 and a steam rate of 17.66.

grams as a whole present no unusual features. The variation in the steam chest pressure at mid-stroke is noticeable in the high-speed tests, Nos. 3842 and 3838. This was also characteristic of the steam chest pressures obtained from Class E6s locomotive No. 89 having 14 in. valves. (See Bulletin 21, Par. 105 and 106.)

Indicated Horse-power.

58. The indicated horse-power, Table XI, ranged between 620.3 at a speed of 28.1 m.p.h. and 15 per cent cut-off and 2357.2 at 75 m.p.h and 35 per cent cut-off, but as we will show, higher horse-powers were later obtained with this locomotive. The coal rate per i.h.p. hour did not exceed 3.6 lb and with the exception of four tests the coal consumption was below 2.9 lb. per i.h.p. hour. The steam rate per i.h.p. hour ranged between 16.07 and 20.56 lb.

Superheat.

59. The temperature of the steam in the branch pipe reached a maximum of 635.7° F., which represents a superheat of 251.3°. The general tendency was for the superheat to remain below 230° F., Table XII. Thus, as shown by Fig. 27, little improvement over the E6s No. 89 has really been obtained in this respect, for there is not much difference in the superheat obtained in the two locomotives, although the 51 has about 122 sq. ft. more superheating surface. The superheat did not fall below 137° in either case.

Water and Coal Rates and Indicated Horse-power.

60. As shown by Fig. 28 the steam per indicated horse-power for the two locomotives is nearly the same up to a horse-power of 1800. At higher horse-powers the 51 shows a slight increase in steam per horse-power, but it is the more economical of the two within what might be called the normal working range or between 1200 and 2000 indicated horse-power. On the diagram X shows tests with the 51 made later than the first series.

61. In Fig. 29 the coal rate for the 51 is lower than for the 89 at all horse-powers. The most economical range in power seems to be between 1200 and 1600 indicated horse-power, where the coal rate is about 2 lb. per horse-power. The curve for the 89 as shown in Fig. 29, has been slightly changed at its right hand end from that shown in Bulletin 21, so that it is more nearly representative of the average rather than of the lower points.

62. The curve for the 51 is more nearly parallel to that for the 89 than it would be with the curve for the 89 in its original form. It is evident, then, that the 51 shows, at horse-powers above 1800, that the larger cylinders use slightly more steam than is the case with the 89, but in coal per horse-power the 51 shows a better performance than the 89 at all

M. P. 470—A

LOCOMOTIVE:
TYPE 4-4-2
CLASS E6s No. 51

SHEET NO. P1523

PENNSYLVANIA RAILROAD COMPANY
PHILADELPHIA, BALTIMORE & WASHINGTON RAILROAD COMPANY
NORTHERN CENTRAL RAILWAY COMPANY
WEST JERSEY & SEASHORE RAILROAD COMPANY
TEST DEPARTMENT

Bulletin No. 27

Tests of a Class E6s Locomotive. ALTOONA, PA. 8-24-1914

SUPERHEAT AND WATER RATE.

Test No.	Test Designation	Draft, Front of Diaphragm Inches of Water	Indicated Horse power Hour	B.t.u. in Steam Per Indicated Horsepower Hour	Superheated Steam Per Indicated Horsepower Hour, Pounds	Dry Coal Per Indicated Horsepower Hour, Pounds	Superheat in Branch Pipe
		222	379		381	380	230
3854	120-15-F	2.0	620.3	24636	19.86	2.38	137.0
3855	160-15-F	2.4	776.1	24668	19.90	2.30	143.2
3832	240-15-F	2.9	1011.7	22980	18.41	2.02	145.6
3836	200-15-F	2.5	934.7	23207	18.56	2.01	150.1
3852	120-25-F	3.0	933.2	24830	19.94	1.98	151.8
3833	160-25-F	4.1	1116.2	23946	19.16	2.15	152.3
3846	320-15-F	4.0	1245.1	21582	17.25	1.75	155.6
3845	280-15-F	3.2	1173.7	21360	17.02	1.85	159.4
3841	360-15-F	4.0	1511.1	20184	16.07	1.66	160.2
3837	200-25-F	4.7	1351.4	22773	18.15	2.01	164.7
3851	120-45-F	7.0	1452.5	25845	20.56	2.46	170.0
3847	120-35-F	5.1	1256.9	24577	19.58	2.24	172.5
3844	240-25-F	5.9	1484.6	22704	17.96	2.00	178.8
3835	160-35-F	6.8	1597.9	23366	18.43	2.18	184.2
3850	160-45-F	9.3	1823.3	24481	19.53	2.54	186.5
3853	120-45-F	6.7	1459.1	24787	19.57	2.27	192.0
3834	320-25-F	7.2	1750.9	21664	17.05	1.91	193.8
3840	360-25-F	7.9	1924.2	21604	16.96	2.05	197.9
3831	240-35-F	10.2	2095.3	22081	17.35	2.23	201.6
3848	200-50-F	15.1	2304.8	24635	19.52	3.59	204.2
3849	160-50-F	12.6	2018.0	25305	19.82	3.02	207.6
3839	360-30-F	11.0	2138.9	21565	16.89	2.84	210.3
3842	280-35-F	11.2	2209.3	22722	17.72	2.40	215.6
3838	320-35-F	12.9	2357.2	22654	17.66	2.52	216.0
3806	280-25-F	6.0	1667.4	20688	16.08	1.90	217.0
3807	200-35-F	7.5	1879.5	21167	16.37	2.19	226.7
3843	360-35-F	13.8	2252.7	23383	18.16	3.36	229.9
3809	200-45-F	10.7	2151.0	23000	17.70	2.86	245.6
3810	240-45-F	12.5	2302.1	23281	17.90	3.10	246.7
3811	280-40-F	13.0	2356.0	21684	16.64	2.86	251.3

SHEET NO. P1523

Table XII.

SUPERHEAT AND WATER RATE.

There is a slight reduction in the water rate as the superheat increases. This decrease is not uniform on account of the effect of cut-off.

Fig. 27.

SUPERHEAT AND EVAPORATION.

There is little difference between the two locomotives in superheat, and with each it is all at times above 100 degrees.

Fig. 28.

WATER RATE AND INDICATED HORSE-POWER.

The steam or water rates are much alike for the two locomotives up to about 1600 i.h.p. Beyond this point the rate of the 51 rises somewhat, but the 51 shows good economy over a range of power between 1200 and 2000 or where it is most likely to be operated under normal conditions. The maximum horse-power of the 50 is 2350 and of the 51, [illegible].

Fig. 29.

COAL RATE AND INDICATED HORSE-POWER.

The coal per horse-power is lower for locomotive 51 at all rates. This effect is due to the better boiler performance of the 51.

horse-powers. This would appear to be due to the increased efficiency of the boiler of the 51, the increase in efficiency being sufficient to overcome the slight loss due to the larger cylinders, and the locomotive as a whole is considerably improved.

63. A further comparison of these two locomotives is shown in Fig. 30, where curves are drawn for the coal fired per hour and the indicated horse-power produced. Here again the 51 shows its superiority over the 89 in economy of coal, as it has a greater indicated horse-power than the 89 at every rate of firing coal, from 1500 lb. per hour up to 8000 lb. per hour.

64. Locomotive 51 has a remarkably small cylinder clearance volume. It averages 10.4 per cent of the piston displacement for the four ends of the cylinders. No. 89 has an average clearance of 14.3 per cent, but the effect of this reduction in clearance can not be determined from the tests.

65. The maximum indicated horse-power was obtained at a speed of 320 r.p.m. (75 m.p.h) with 41.5 per cent actual cut-off. The indicated horse-power under these test conditions was 2357.2. In the case of locomotive No. 89 with 22-in. cylinders, a maximum indicated horse-power of 2355.2 was obtained at a speed of 360 r.p.m. or 84 m.p.h. with an actual cut-off of 36.1 per cent. It is evident that the tests show locomotive No. 51 to be superior to 89 in starting force by about 11 per cent.

66. Locomotive No. 51 has been returned to the test plant (December, 1914), and without any changes in the locomotive, tests have been made with indicated horse-powers above those of the earlier tests, as the following table will show.

TESTS OF LOCOMOTIVE NO. 51.

First Tests, June and July, 1914.

Test No.	Test Designation	Duration of Test, Minutes	Boiler Pressure	Superheat Degrees, Fahr.	Steam to Engines, Pounds per Hour	Indicated Horse-power	Dry Coal per i. h. p. hour, Lb.	Steam per i. h. p. hour, Lb.
3832	240-15-F	120	206.0	145.6	18 627	1 011.7	2.0	18.4
3810	240-45-F	60	202.6	246.7	41 208	2 302.1	3.1	17.9
3848	200-50-F	60	204.9	204.2	44 530	2 304.8	3.6	19.3
3838	320-35-F	60	206.0	216.0	41 631	2 357.2	2.5	17.7
Second Tests, December, 1914.								
3866	240-15-F	120	205.0	139.8	17 826	1 015.8	2.0	17.6
3868	240-45-F	30	204.5	179.6	41 986	2 366.3	2.9	17.7
3869	240-47-F	60	201.7	228.3	44 583	2 488.9	3.4	17.9

Fig. 30.

COAL FIRED AND INDICATED HORSE-POWER.

Locomotive No. [illegible] produces more power than the [illegible] at every rate of firing.

Piston Speed and Water Rate.

67. Plotting the steam consumption per i.h.p. hour as abscissæ with the piston speed in feet per minute as ordinates for locomotives Nos. 89 and 51 in Fig. 31, it is seen that a single curve is fairly representative of the performance of both locomotives, and that there is an improvement in steam per horse-power with an increase in piston speed up to 1200 ft. per minute.

Efficiency of Engines.

68. We will now consider the performance of the engines in relation to the heat supplied to them in the steam, comparing the results with ideal conditions which will be assumed. There are certain heat losses which occur in the cylinders of the actual engine, and the greatest of these is, of course, the heat discharged in the exhaust steam, and compared with this all of the other losses combined are small. There are also losses due to initial condensation, although this is probably overcome by superheating. The clearance in the cylinder is the cause of loss of steam and its heat contents, as the clearance space requires a certain volume of steam to fill it, and this steam is not economically used during the working stroke, and is to a greater or less extent lost during the exhaust stroke. The clearance in locomotive No. 51 is remarkably small, however. There are further losses due to radiation and leakage. A high piston speed would tend to reduce the radiation loss, for while the area of surface of the cylinders from which the radiation takes place remains the same, the heat entering the cylinders increases with the piston velocity; thus the heat radiated would tend to remain constant and become a smaller and smaller proportion of the total heat involved as the piston speed increased.

69. As an aid to the study of the conditions in the cylinders, we have prepared the Tables XIII and XIV, which show for each locomotive separately: the pressures and temperatures under which the engines work; the horse-power developed; the ideal water rate and the actual rate. The ideal rate is that weight of steam which would be used by an ideal non-conducting engine, working under the conditions of pressure and temperature of the actual engine, but operating according to the Rankine cycle, which requires that the steam be admitted without fall of pressure or temperature up to the point of cut-off and be then permitted to expand adiabatically in the cylinder (without loss or gain of heat) to the back or exhaust pressure. The thermal efficiency of engines shows how closely the actual engine comes to converting all of the heat in the steam into work. The ideal engine which we are considering and which operates according to the Rankine cycle does not convert all or nearly all of the heat in the steam into work, but, like the actual engine, it discharges heat in the exhaust steam and therefore its efficiency is never 100 per cent.

Fig. 31.

PISTON SPEED AND WATER RATE.

The water rates at the various piston speeds have not been materially changed by increasing the size of the cylinders on locomotive No. 51 as its water rate is very similar to that obtained from No. 50 equipped with 22-inch cylinders.

M. P. 470–A

LOCOMOTIVE:
TYPE 4-4-2
CLASS E6s No. 51

PENNSYLVANIA RAILROAD COMPANY

PHILADELPHIA, BALTIMORE & WASHINGTON RAILROAD COMPANY
NORTHERN CENTRAL RAILWAY COMPANY
WEST JERSEY & SEASHORE RAILROAD COMPANY

TEST DEPARTMENT

SHEET No. P1529

Bulletin No. 27

Tests of a Class E6s Locomotive. ALTOONA, PA. 12-1-1914

EFFICIENCY OF ENGINES.

Test No.	Test Designation	Press. Lbs. Per Square Inch Absolute		Indicated Horse power	Water Rate Pounds Per I. H. P.		Super-heat in Branch Pipe	B.t.u. Consumed Per I. H. P. Hour		Thermal Efficiency of Engines Per cent	Efficiency of Engs. Based on Rankine Cycle, Per cent
		Branch Pipe	Exhaust		Ideal	Actual		Ideal Engines	Actual Engine		
3854	120-15-F	215.6	14.9	620.3	11.9	19.9	137.0	13075	21864	11.6	59.8
3855	160-15-F	215.7	15.2	776.1	11.9	19.9	143.2	13075	21864	11.6	59.8
3852	120-25-F	215.5	16.0	933.2	12.1	19.9	151.8	13205	21898	11.6	60.3
3836	200-15-F	216.3	14.7	934.7	11.6	18.6	150.1	13025	20531	12.4	63.4
3832	240-15-F	216.9	14.4	1011.7	11.6	18.4	145.6	12846	20376	12.5	63.0
3833	160-25-F	216.0	16.1	1116.2	12.0	19.2	152.3	13205	21128	12.1	62.5
3845	280-15-F	216.1	15.1	1173.7	11.7	17.0	159.4	12973	18850	13.5	68.8
3846	320-15-F	216.1	14.5	1245.1	11.6	17.2	155.6	12973	19071	13.4	68.0
3847	120-35-F	213.8	16.6	1256.9	12.1	19.4	172.5	13396	21478	11.9	62.4
3841	360-15-F	216.4	15.0	1311.1	11.4	16.1	160.8	12973	17852	14.3	72.7
3837	200-25-F	214.8	16.4	1351.4	12.0	18.2	164.7	13264	20116	12.7	65.9
3851	120-45-F	211.5	18.3	1452.5	12.5	20.6	170.0	13687	22738	11.2	60.2
3853	120-45-F	212.4	17.3	1459.1	12.1	19.6	192.0	13402	21889	11.6	61.2
3844	240-25-F	214.0	17.5	1484.6	12.1	18.0	178.8	13531	19964	12.8	67.8
3835	160-35-F	214.0	18.4	1597.9	12.2	18.4	184.2	13531	20407	12.5	66.3
3808	280-25-F	212.5	18.0	1667.4	12.0	16.1	217.0	13539	18014	14.1	75.2
3834	320-25-F	214.0	19.0	1750.9	12.3	17.1	193.8	13618	19087	13.3	71.3
3850	160-45-F	210.4	20.6	1823.3	12.7	19.3	186.5	14699	21330	11.9	68.9
3807	200-35-F	211.8	18.8	1879.5	11.9	16.4	226.7	13459	18706	13.6	72.0
3840	360-25-F	213.0	19.3	1924.2	12.4	17.0	197.9	13727	18972	13.4	72.4
3849	160-50-F	207.8	21.6	2018.0	12.4	19.8	207.6	14398	21929	11.6	65.7
3831	240-35-F	213.7	20.0	2095.3	12.4	17.4	201.6	13919	19375	13.1	71.8
3809	200-45-F	211.0	21.2	2131.0	12.4	17.7	245.6	13848	19709	12.9	70.3
3839	360-30-F	210.4	21.6	2138.9	12.9	16.9	210.3	14400	18720	13.6	76.9
3842	280-35-F	209.5	22.1	2209.3	12.7	17.7	215.6	14400	19606	13.0	73.4
3843	360-35-F	199.2	24.0	2252.7	13.4	18.2	229.9	14752	20495	12.4	72.0
3810	240-45-F	205.6	24.0	2302.1	13.1	17.9	246.7	14527	20157	12.6	72.1
3848	200-50-F	204.2	25.1	2304.8	13.6	19.3	204.2	15177	21226	12.0	71.5
3811	280-40-F	206.1	23.6	2356.7	12.8	16.6	251.3	14540	18710	13.6	77.7
3838	320-35-F	209.1	23.4	2357.2	13.1	17.7	216.0	14587	19560	13.0	74.6

SHEET No. P1529

Table XIII.

THERMAL EFFICIENCY OF ENGINES—LOCOMOTIVE No. 51.

It should be possible under ideal conditions for the engines to run with from 11.4 to 13.6 pounds of steam, but they use from 16.1 to 20.6 pounds. The thermal efficiency shows how near the engines come to utilizing all of the heat in the steam, and the last column shows the degree of perfection of the engines when compared with an ideal engine operating according to the Rankine cycle.

M. P. 679—A

LOCOMOTIVE: TYPE 4-4-2 CLASS E6a No. 89

SHEET No. P1530

PENNSYLVANIA RAILROAD COMPANY

PHILADELPHIA, BALTIMORE & WASHINGTON RAILROAD COMPANY
NORTHERN CENTRAL RAILWAY COMPANY
WEST JERSEY & SEASHORE RAILROAD COMPANY

TEST DEPARTMENT

Bulletin No. 27

Tests of a Class E6a Locomotive. ALTOONA, PA. 12-1-1914

EFFICIENCY OF ENGINES.

Test No.	Test Designation	Press. Lbs. Per Square Inch Absolute: Branch Pipe	Press. Lbs. Per Square Inch Absolute: Exhaust	Indicated Horse power	Water Rate Pounds Per I. H. P.: Ideal	Water Rate Pounds Per I. H. P.: Actual	Super-heat in Branch Pipe	B.t.u. Consumed Per I. H. P. Hour: Ideal Engines	B.t.u. Consumed Per I. H. P. Hour: Actual Engines	Thermal Efficiency of Engines Per cent	Efficiency of Engs. Based on Rankine Cycle, Per cent
2801	120-20-F	216.9	15.6	756.1	12.0	21.0	141.2	13145	23003	11.1	57.1
2818	120-25-F	214.6	14.3	973.7	11.4	19.1	164.2	12679	21243	12.0	59.7
2802	120-30-F	215.2	14.8	1055.1	11.6	19.8	156.9	12861	21952	11.6	58.6
2826	200-20-F	210.8	15.8	1228.8	11.8	17.4	177.6	13161	19406	13.1	67.8
2814	160-25-F	214.7	14.6	1265.1	11.4	17.9	180.1	12753	20025	12.7	63.7
2803	160-30-F	214.9	15.2	1356.4	11.6	18.4	169.9	12919	20492	12.4	63.0
2817	120-40-F	211.8	15.9	1356.7	11.5	18.3	205.1	12936	20586	12.4	62.8
2816	240-20-F	213.6	16.1	1424.0	11.7	16.4	189.8	13106	18371	13.9	71.3
2804	160-35-F	213.5	16.7	1489.2	12.0	18.4	178.4	13345	20463	12.4	65.2
2807	200-25-F	212.9	17.0	1529.3	11.9	17.2	194.1	13291	19211	13.3	69.2
2819	280-20-F	210.3	16.7	1554.1	11.3	16.2	197.9	12673	18168	14.0	69.8
2824	320-20-F	201.6	18.6	1721.4	12.4	17.4	192.3	13759	19307	13.2	71.3
2813	240-25-F	210.9	18.5	1735.4	12.1	16.8	210.0	13501	18745	13.6	72.0
2827	320-20-F	210.6	17.9	1741.5	12.1	16.7	199.8	13536	18682	13.6	72.5
2815	200-35-F	211.8	18.3	1844.7	12.1	17.1	220.7	13536	19128	13.3	70.8
2811	240-30-F	211.3	18.8	1875.5	12.1	17.1	206.9	13501	19080	13.3	70.8
2808	160-50-F	211.7	20.4	1880.0	12.4	19.5	211.0	13804	21707	11.7	63.6
2821	280-25-F	208.3	19.6	1967.2	12.2	16.3	228.3	13876	18540	13.7	74.8
2838	360-20-F	209.8	22.0	1993.6	12.2	15.8	226.1	13815	17892	14.2	77.2
2810	200-60-F	186.7	22.6	1994.3	13.3	19.1	233.6	14657	21048	12.1	69.6
2809	200-50-F	190.0	21.9	2016.0	13.1	18.9	236.7	14798	21349	11.9	69.3
2825	240-38-F	201.3	23.5	2043.7	13.2	18.0	232.9	14934	20365	12.5	73.3
2812	280-30-F	209.4	21.3	2065.4	12.5	16.8	222.8	13876	18650	13.7	74.4
2823	320-25-F	203.7	22.5	2116.8	12.8	16.4	230.6	14452	18517	13.8	78.0
2820	280-38-F	206.6	23.6	2265.1	12.9	17.0	238.8	14541	19162	13.3	75.9
2840	360-25-F	207.0	24.6	2350.1	13.4	16.0	233.7	15074	17998	14.1	83.8
2839	360-30-F	192.2	27.4	2365.2	14.1	16.3	211.4	15424	17851	14.3	86.5

SHEET No. P1530

Table XIV.

THERMAL EFFICIENCY OF ENGINES—LOCOMOTIVE No. 89.

The engines convert into work between 11.1 and 14.3 per cent. of the heat in the steam.

70. The efficiency of the Rankine or any cycle is expressed in a general way by the equation:

$$E=\frac{T_1-T_2}{T_1}$$

where T_1 equals the absolute temperature of steam supply and T_2 the absolute temperature of the exhaust steam.

Taking Test No. 3844 as a representative one, the conditions are: Steam pressure 214.0 lb., temperature 387.6, superheat 178.8, absolute temperature 1026.04. Exhaust pressure 17.5 lb., temperature 220.9, absolute temperature 680.54.

Substituting these temperatures:

$$E=\frac{1026.04-680.54}{1026.04}=33.67 \text{ per cent.}$$

71. The efficiency of our ideal engine for this test is then 33.67 per cent, and this is an efficiency that the actual engine can not possibly exceed. In the last column of the table we show how closely the actual engine approaches the ideal. For Test No. 3844 the actual engine has an efficiency which is 67.8 per cent of the ideal. In this case the 33.67 per cent efficiency is that taken as representing 100 per cent.

72. While from 11.6 to 14.1 per cent of the actual heat in the steam is utilized or turned into work as shown by the thermal efficiency of the engines, the engines approach within 23 per cent of the perfect engine as shown in the last column. From these tables the two diagrams, Figs. 32 and 33, have been plotted.

73. The points in Fig. 32 show that, as the power increases there is an increase in the thermal efficiency with a later falling off as the power is further increased. When the output is between 600 and 2400 i.h.p. the actual engines of these locomotives are using from 11 to 14 per cent of the heat in the steam and discharging the rest in the exhaust.

74. The diagram in Fig. 33, where the efficiencies of the engines when working according to the Rankine cycle, are compared, shows that when the evaporation is low the economy is about 60 per cent. This means that the ideal engine, if it replaced the actual engine, could perform the same functions under identical conditions with approximately 60 per cent of the steam now used, that is, the actual engine is using about 40 per cent more heat than would be necessary with the use of an engine conforming to the Rankine cycle.

75. As the rate of using steam increases with increased speed and shortened cut-off, this inefficiency becomes less and the performance of the actual engine approaches the ideal as a limit.

76. Table XIV for locomotive No. 89 shows the efficiency to reach 86.5 per cent, or the actual engine to approach within 13.5 per cent of the performance of the ideal engine. Such high efficiencies may be in error due to the necessary shortness of tests, as they occur only at the highest

Fig. 32.

THERMAL EFFICIENCY OF ENGINES.

It is shown here that the engines convert into useful work between 11 and 14 per cent. of the heat available in the steam supply. There is little difference between the two locomotives in thermal efficiency.

Fig. 33.

EFFICIENCY OF ENGINES BASED ON THE RANKINE CYCLE.

This is a comparison of the actual engines with engines operating on the Rankine cycle, showing that the actual engines have an efficiency that is between 50 and 60 per cent. of that of the Rankine engine.

speed or at eighty-five miles per hour. On the other hand the higher speeds require a short cut-off and this means an expansion that is more nearly adiabatic.

77. The methods used in calculating Tables XIII and XIV are those of the A. S. M. E. Code for Engine Tests.

78. Taking, for example, Test No. 3844, the alsolute steam pressure is 214 lb. and the superheat 178.8°. On the total Heat-Entropy (Mollier) Diagram for saturated and superheated steam, we find the total heat contents of a pound of this steam to be 1300 B.t.u.

79. Following down a line of constant entropy (the entropy is constant for adiabatic expansion) to the back pressure of 17.5 lb., we find the heat in the exhaust steam to be 1090 B.t.u.

80. Then 1300 — 1090 = 210 B.t.u. consumed by the engines per pound of steam. The heat equivalent of an indicated horse-power hour is 2546.56 B.t.u. and dividing this by 210, the heat used, we have 12.12 lb. of steam as the water rate of the ideal engine. The ideal engines would consume 13.531 B.t.u. per i.h.p. hour.

81. The actual engine consumed 19,964 B.t.u., the heat in the steam above the heat in an ideal feed water, the temperature of which is taken as that of the exhaust steam, and by dividing 13,531 by 19,964 and multiplying by 100 we have 67.8 per cent as the efficiency of the engines based on the Rankine cycle.

82. The very large quantity of heat rejected or discharged in the exhaust from the actual engine (from 86 to 89 per cent) and the possibility, even with the ideal engine, of recovering but some 30 per cent of the heat supplied, although familiar facts (see discussion by H. H. Vaughn, Proceedings A. Ry. M. M. Association, for 1905, page 95) characteristic of all simple engines, have a new significance, when superheating is employed, for while more heat is furnished to the engines and a better performance obtained per pound of steam, there is besides more heat wasted in the exhaust steam than when using saturated steam. Bearing this in mind, the greater advantage to be derived through the use of a feed water heater when using superheated steam is readily apparent, in that there is more heat available for the heater at any power rate than for the same power when the engines are using saturated steam. This is merely a confirmation of a statement made by Robert Garbe in his work: "The Application of Highly Superheated Steam to Locomotives" (page 12).

Superheated and Saturated Steam at Equal Water Rates.

83. It was shown in Bulletin 21 that at a speed of 38 m.p.h. the superheated steam locomotive No. 89, Class E6s, developed over 400 more indicated horse-power with 50 per cent cut-off than the saturated steam locomotive No. 5075, Class E6, when running at the same speed with 30 per cent cut-off, although both locomotives evaporated practically the same amount of water per hour. Both locomotives had cylinders at that time

22 in. in diameter, thus the increase in power was due only to the use of highly superheated steam.

84. The following data in tabulated form are presented to show that not only is this greater power possible but the advantage of a shorter cut-off is offered over a certain range when the diameter of the superheater locomotive cylinder is increased above the requirements for saturated steam.

85. The table shows the performance of the new design of E6s locomotive having 23½-in. cylinders, the E6s with 22-in. cylinders and the saturated steam locomotive Class E6, with 22-in. cylinders, at water rates as nearly similar as possible when running at a speed of 200 r.p.m. or 48 m.p.h. It gives the mean effective pressure in pounds per square inch, nominal cut-off in per cent of stroke, superheat, steam per hour to engines in pounds, steam per i.h.p. hour in pounds and the indicated horse-power.

COMPARATIVE PERFORMANCE AT EQUAL WEIGHTS OF SATURATED AND SUPERHEATED STEAM.

Speed — 48 m.h.p.

Locomotive No.	51	89	5075
Class	E6s	E6s	E6
Steam per hour, pounds	37 713	38 028	37 335
Steam per i.h.p. hour, pounds	17.70	18.86	24.14
Indicated horse-power	2 131	2 016	1 546
Mean effective pressure	95.97	104.1	79.0
Cut-off	45	55	32
Superheat	245.6	237.0	None

86. It is observed that locomotive No. 51 attained 585 indicated horse-power above that of the E6 saturated steam locomotive, and 115 horse-power more than was produced by locomotive No. 89 using superheated steam in the smaller cylinder, when all use the same weight of steam per hour. Further, it is interesting to note the water rate per i.h.p. hour of locomotive No. 51 which is the lowest of the three. An increase in the size of the locomotive cylinders on No. 51 brought about this favorable performance at 10 per cent less cut-off than was used with locomotive No. 89 when using very nearly the same amount of water per hour.

87. This is what should be expected from a superheated steam locomotive with a proper cylinder diameter, but the fact that the performance of locomotive No. 51 falls below that of locomotive No. 89 at 360 r.p.m. as well as its tendency to fall off at the higher speeds especially, leads us to believe that there is something in its present design that is detrimental to its good performance at the higher speeds.

LOCOMOTIVE PERFORMANCE.

DYNAMOMETER RECORDS.

88. The comparison of results of locomotives Nos. 89 and 51 is continued in this discussion of the performance of the locomotive at the drawbar, and satisfactory results are shown for No. 51, which is of the improved design. We have already shown under the discussion of boiler results, that an improvement has been made in the boiler which has resulted in a better efficiency. When we come to consider the dynamometer results in Table XV and Figs. 34 and 35, we find the high efficiency of the boiler reflected in a coal rate per dynamometer horse-power which is lower than that of the 89. Further, the expected increase in drawbar horse-power by the larger cylinders and the greater weight of steam supplied has been realized, but to what extent is not easily determined, as there are apparent discrepancies in the results for dynamometer horse-power.

89. The two locomotives are very nearly alike as to wheel arrangement and all the moving parts of the engines, so that there is no reason to expect any great difference in the machine friction. Where the indicated horse-powers are alike, we should expect to find the drawbar pull and drawbar horse-power the same for both. The large increase for the 51 in such cases must then be due either to errors in the reading of the drawbar pull or a very much decreased friction.

90. A second series of tests with the 51 when compared with the earlier tests show results as follows:

TESTS OF LOCOMOTIVE NO. 51.
First Tests, June and July, 1914.

Test No.	Test Designation	Speed, Miles per Hour	Draw-Bar Pull, Pounds	Dynamometer Horse-power	Coal per d.h.p. Hour, Pounds	Steam per d.h.p. Hour, Pounds	Machine Efficiency of Locomotive, Per Cent.
3832	240–15-F	56.4	5 201	782.6	2.6	23.8	77.4
3810	240–45-F	56.4	13 691	2 060.2	3.5	20.0	89.5
3848	200–50-F	46.9	17 293	2 162.3	3.8	20.6	93.8
3838	320–35-F	75.0	10 129	2 026.4	2.9	20.5	86.0
Second Tests, December, 1914.							
3866	240–15-F	55.7	4 819	716.4	2.8	24.9	70.5
3868	240–45-F	55.7	14 297	2 125.3	3.2	19.8	89.8
3869	240–47-F	55.7	15 138	2 250.4	3.8	19.8	90.4

The machine efficiency, however, shows but little variation from the earlier tests.

M. P. 479—A

LOCOMOTIVE:
TYPE 4-4-2
CLASS E6s No. 51

PENNSYLVANIA RAILROAD COMPANY

PHILADELPHIA, BALTIMORE & WASHINGTON RAILROAD COMPANY
NORTHERN CENTRAL RAILWAY COMPANY
WEST JERSEY & SEASHORE RAILROAD COMPANY

TEST DEPARTMENT

Bulletin No. 27

SHEET No. P1533

Tests of a Class E6s Locomotive. ALTOONA, PA. 8-24-1914

DRAWBAR HORSEPOWER.

Test No.	Test Designation	Duration of Test, Mins.	Speed M.P.H.	Drawbar Pull in Pounds	Dynamometer or Drawbar Horsepower	Dry Coal Per Dynamometer Horsepower Hour	Superheated Steam Per Dynamometer Horsepower Hour	B.t.u. in Steam Per Drawbar Horsepower Hour	Thermal Efficiency of Locomotive Per cent
			199	265	383	384	385		399
3854	120-15-F	120	28.1	6414	480.0	3.1	25.7	31829.8	5.8
3855	160-15-F	120	37.4	5972	595.9	2.7	25.9	32105.4	6.6
3836	200-15-F	120	46.9	5226	653.5	2.9	26.5	33134.5	6.2
3852	120-25-F	120	28.1	10276	769.0	2.4	24.2	30134.1	7.5
3832	240-15-F	120	56.4	5201	782.6	2.6	23.8	29707.6	6.8
3841	360-15-F	30	84.4	3453	777.2	2.8	27.1	34037.1	6.3
3845	280-15-F	90	65.6	4754	832.2	2.6	24.0	30120.2	6.9
3846	320-15-F	60	75.0	4169	834.1	2.6	25.7	32191.6	6.9
3833	160-25-F	90	37.5	9603	960.6	2.5	22.3	27869.9	7.1
3837	200-25-F	120	46.9	8312	1039.3	2.6	23.6	29611.4	6.8
3847	120-35-F	120	28.1	15299	1147.8	2.5	21.2	26707.1	7.3
3844	240-25-F	90	56.3	7592	1139.2	2.6	23.4	29580.9	6.9
3840	360-25-F	30	84.4	5389	1212.9	3.2	26.9	34266.3	5.5
3851	120-45-F	60	28.1	17782	1334.1	2.7	22.4	28157.9	6.7
3853	120-45-F	60	28.1	18037	1349.7	2.5	21.2	26851.3	7.3
3808	280-25-F	90	65.8	7905	1387.8	2.3	19.3	24830.4	7.8
3835	160-35-F	120	37.5	14677	1468.2	2.4	20.1	25483.2	7.5
3834	320-25-F	60	75.0	7211	1442.7	2.3	20.7	26302.2	7.6
3839	360-30-F	30	84.4	6547	1473.5	4.1	24.5	31370.8	4.3
3807	200-35-F	60	47.0	12655	1586.9	2.6	19.4	25085.2	6.9
3843	360-35-F	30	84.4	7288	1640.3	4.6	24.9	32061.7	3.8
3850	160-45-F	60	37.5	17066	1707.1	2.7	20.6	26089.2	6.6
3831	240-35-F	60	56.4	11548	1737.7	2.7	20.9	26598.8	6.6
3842	280-35-F	60	65.6	10639	1862.4	2.8	21.0	26927.9	6.2
3809	200-45-F	60	47.0	15224	1909.1	3.2	19.8	25729.3	5.5
3849	160-50-F	60	37.5	19410	1941.6	3.1	20.6	26301.1	5.7
3838	320-35-F	60	75.0	10129	2026.4	2.9	20.5	26296.8	6.1
3810	240-45-F	60	56.4	13691	2060.2	3.5	20.0	26012.4	5.1
3811	280-40-F	60	65.8	11695	2053.2	3.3	19.1	24890.2	5.4
3848	200-50-F	60	46.9	17293	2162.3	3.8	20.6	26267.1	4.7

SHEET No. P1533

Table XV.

DYNAMOMETER OR DRAWBAR HORSE-POWER.

The maximum horse-power was 2162.3. The coal per horse-power ranges between 2.3 and 4.6 pounds, with most of the rates below 2 pounds. The steam or water rate per horse-power ranges between 19.1 and 27.1 pounds.

Fig. 34.

DYNAMOMETER HORSE-POWER AND STEAM.

The performance of the 51 is slightly better than that of the 50, and the 51 develops a maximum horse-power which is 17 per cent. above that of the 50.

Fig. 35.

DYNAMOMETER HORSE-POWER AND COAL.

The coal rate of the 51 is decidedly better than that of the [illegible] at all horse-powers.

91. The maximum drawbar or dynamometer horse-power obtained was 2250.4 with a coal rate of 3.8 lb. per d.h.p. hour and a steam rate of 19.8 lb. per d.h.p. hour.

92. The coal rate for all tests was generally below 3 lb., Table XV. The maximum horse-power for the 51 is about 17 per cent above that of the 89. Referring to the curves in Fig. 35 which show the coal rates per dynamometer horse-power for the two locomotives, we find that the whole performance of the 51 is far better than that of the 89.

93. With these two locomotives so nearly alike and fired with the same grade of coal, the rate of firing and the drawbar or dynamometer horse-power derived from the fuel fired, should give an accurate comparison of their overall efficiency. In Fig. 36 such a comparison is made and we find that at all rates of firing the 51 shows the highest output, with a maximum horse-power of about 2250, where that of the 89 is 1850.

Drawbar Pull.

94. This superheated steam locomotive No. 51, with large cylinders developed a higher drawbar pull than the 89, and this advantage was maintained from starting, to a speed of 85 m.p.h. or throughout its whole range of operation, Fig. 37.

95. The following table gives the drawbar pull in pounds obtained at low speeds and long cut-offs, illustrating the high pull possible with this locomotive having a weight on drivers of 133,100 lb. and a factor of adhesion of 4.52.

Tests for Drawbar Pull at Low Speeds.

Speed		Cut-off in Per Cent	Drawbar Pull, Pounds
R.P.M.	M.P.H.		
60	14.0	82—Full gear.	30 917
80	18.7	82—Full gear.	30 027
100	23.4	82—Full gear.	28 680
120	28.1	66	23 735
160	37.4	58	20 055

96. The cylinder enlargement has proven advantageous especially as a means of increasing the starting force. It is recognized that these Atlantic type locomotives are capable of hauling very heavy trains at high speed, but on account of their comparatively light weight on drivers the opinion has prevailed that it would be difficult to utilize this available power in the starting of very heavy trains.

97. Experience in road service has demonstrated the possibility of exerting the estimated tractive effort of these locomotives when working

Fig. 36.

DYNAMOMETER HORSE-POWER AND COAL.

At every rate of firing the remodeled locomotive No. 51 develops a greater horse-power than the 50. At a rate of firing of 7000 pounds per hour the horse-power of the 51 is 2100 where that of the 50 is [illegible].

Fig. 37.

DRAWBAR PULL.

Locomotive 61 with large cylinders shows a higher drawbar pull than the 60, and this advantage is maintained up to a speed of 25 miles per hour.

under favorable rail conditions, and the fact that they are giving satisfaction in heavy express service is interesting, when their low ratio of adhesion is considered.

98. Locomotive No. 89 with 22-in. cylinders and having a weight on drivers of 141,000 lb. was designed with a ratio of adhesion of 5.48, as a saturated steam locomotive. With the use of superheated steam for which large cylinders are suitable, this ratio has been decreased to 4.52.

99. Fig. 38 shows the drawbar pull that may be expected from this locomotive at various speeds when operating at cut-offs of 15, 25, 35, 45 and 50 per cent of the stroke. The circles represent regular tests and the crosses indicate short runs which were made for the purpose of obtaining the maximum drawbar pulls at low speeds and cut-offs beyond 50 per cent of the stroke.

Machine and Locomotive Efficiency.

100. The machine efficiency, Table XVI, ranged between 59.3 and 96.2. A comparison with locomotive No. 89, Fig. 39, shows a higher machine efficiency for the 51.

101. The thermal efficiency of the locomotive ranged between 3.8 and 7.8 per cent. The higher thermal efficiency for the 51, Fig. 39, is a result of its efficient boiler performance.

102. It is observed that the machine and thermal efficiencies for the 51 fall at approximately the same rate as those of the 89 with a corresponding increase in speed.

103. In Bulletin 21 (page 152), certain changes in the former E6s locomotive were recommended from general considerations and as a result of the earlier tests. Briefly, the recommendations were that a new design should include the following:

a.—An exhaust nozzle giving better draft conditions than the plain circular form.

b.—A screw type of reversing gear.

c.—An enlargement of the cylinders to such a size that the maximum horse-power may be developed at a cut-off not exceeding 30 per cent.

d.—An increase in tube length.

e.—The application of 12-in. diameter piston valves.

f.—A reduction in the width of the center grate bearer.

The locomotive was redesigned in accordance with these recommendations and other suggestions from road service and the results of the new series of tests have justified the course taken.

Fig. 38.

DRAWBAR PULL.

The curves which are drawn through points of the same cut-off show that the pull decreases as the speed is increased. This effect is probably due to losses of pressure in the cylinder as the piston speed is increased. The circles represent regular tests and X short runs in which the drawbar pull only was obtained.

M. P. 479—A

LOCOMOTIVE:
TYPE 4-4-2
CLASS E6s No. 51

SHEET No. P1539

Tests of a Class E6s Locomotive.

PENNSYLVANIA RAILROAD COMPANY

PHILADELPHIA, BALTIMORE & WASHINGTON RAILROAD COMPANY
NORTHERN CENTRAL RAILWAY COMPANY
WEST JERSEY & SEASHORE RAILROAD COMPANY

TEST DEPARTMENT

Bulletin No. 27

ALTOONA, PA. 8-24-1914

MACHINE FRICTION.

Test No.	Test Designation	Duration of Test Minutes.	Machine Friction In					Machine Efficiency Per cent
			Horse power	Mean Effective Pressure, Pounds Per Square Inch	Drawbar Pull Pounds	Steam to Engines Per Hour, Pounds	Dry Coal Fired Per Hour	
			395	396	397			398
3854	120-15-F	120	140.3	10.5	1875	3605.7	434.9	77.4
3852	120-25-F	120	164.2	12.3	2194	3973.6	394.1	82.4
3847	120-35-F	120	109.1	8.2	1454	2512.9	272.8	91.3
3853	120-45-F	60	109.4	8.2	1462	2519.3	273.5	92.5
3851	120-45-F	60	118.4	8.9	1578	2652.2	319.7	91.9
3855	160-15-F	120	180.2	10.1	1806	4667.2	486.5	76.8
3833	160-25-F	90	155.6	8.8	1556	3469.9	389.0	86.1
3835	160-35-F	120	129.7	7.3	1297	2607.0	311.3	91.9
3850	160-45-F	60	116.2	6.5	1162	2393.7	313.7	93.6
3849	160-50-F	60	76.4	4.3	764	1573.8	256.8	96.2
3836	200-15-F	120	281.2	12.7	2249	7451.8	815.5	69.9
3837	200-25-F	120	312.1	14.1	2496	7365.6	811.5	76.9
3807	200-35-F	60	292.6	13.2	2333	5676.4	760.8	84.4
3809	200-45-F	60	221.9	10.0	1770	4393.6	710.1	89.6
3848	200-50-F	60	142.5	6.4	1140	2935.5	541.5	93.8
3832	240-15-F	120	229.1	8.6	1523	5452.6	595.7	77.4
3844	240-25-F	90	345.4	13.0	2302	8082.4	898.0	76.7
3831	240-35-F	60	357.6	13.4	2377	7473.8	965.5	82.9
3810	240-45-F	60	241.9	9.1	1608	4838.0	846.6	89.5
3845	280-15-F	90	341.5	11.0	1951	8196.0	887.9	70.9
3806	280-25-F	90	279.6	9.0	1593	5596.3	643.1	83.2
3842	280-35-F	60	346.9	11.2	1982	7284.9	971.3	84.3
3811	280-40-F	60	303.5	9.8	1729	5796.9	1001.6	87.1
3846	320-15-F	60	411.0	11.6	2055	10562.7	1068.6	67.0
3834	320-25-F	60	308.2	8.7	1541	6379.7	708.9	82.4
3838	320-35-F	60	330.8	9.3	1654	6781.4	959.3	86.0
3841	360-15-F	30	533.9	13.4	2372	14468.7	1494.9	59.3
3840	360-25-F	30	711.3	17.8	3161	19134.0	2276.2	63.0
3839	360-30-F	30	665.4	16.6	2957	16302.3	2728.1	68.9
3843	360-35-F	30	612.4	15.3	2721	15248.8	2817.0	72.8

SHEET No. P1539

Table XVI.

MACHINE FRICTION.

The friction of the locomotive machinery is shown in five different forms. As much as 700 horse-power may be lost in friction of the machine. The loss in drawbar pull is fairly constant and does not appear to increase with the speed except at highest speed. One and one-half tons of coal per hour are at times used to overcome the friction of the locomotive.

Fig. 39.

MACHINE AND LOCOMOTIVE EFFICIENCY.

Locomotive No.51 shows a higher machine and locomotive efficiency than the 29. The higher locomotive efficiency is mainly due to the good boiler performance of the 51.

CONCLUSIONS.

Boiler.

1. The drop or loss in steam pressure between the throttle and steam chest was less than 15 lb. with a maximum flow of steam of 44,600 lb. per hour. (Par. 24.)

2. The highest steam temperature was 635.7°, with a corresponding maximum superheat of 251.3°. The superheat was found to agree closely with that obtained from the earlier design of this boiler. (Par. 25.)

3. The air inlet to the ashpan is somewhat smaller than on the former locomotive, and as a consequence the vacuum in the ashpan was as much as 0.4 in. of water. (Par. 28.)

4. The smokebox temperatures of between 436° and 663° are slightly lower than corresponding ones obtained with the shorter tube boiler on locomotive No. 89. (Par. 29.)

5. The superheater damper appears to be of sufficient area so that the passage for gases is unobstructed. (Par. 32.)

6. A maximum evaporation of 44,600 lb. per hour was shown by the tests. This is an increase of 15 per cent over that of locomotive No. 89. (Par. 40.)

7. The equivalent evaporation per pound of coal and the boiler efficiency of locomotive No. 51 are both about 9 per cent greater than for locomotive No. 89. (Pars. 41 to 44.)

8. An exhaust nozzle having internal projections gave much better results than were obtained with a circular nozzle of equal area. (Par. 48.)

9. The increase in the length of the tube in this boiler, we believe, has resulted in a very considerable improvement in its general performance and efficiency. (Pars. 52 to 55.)

Engines.

10. The engine performance of locomotive No. 51 while in general better than that of the 89 with smaller cylinders, shows a somewhat higher consumption of steam at the higher horse-powers. (Par. 60.)

11. The coal rate per indicated horse-power hour did not exceed 3.6 lb., while the steam rate ranged between 16.07 and 20.56 lb. (Par. 58.)

12. The cylinders of this locomotive are remarkable for their small clearance space. The clearance volume is about 10 per cent of the piston displacement. The effect on the steam consumption of this small clearance can not be definitely determined from these tests. (Par. 64.)

13. The maximum indicated horse-power was obtained at a speed of 320 r.p.m. (75 m.p.h.) and a nominal cut-off of 35 per cent. This maximum power was 2357.2 i.h.p. Later tests show a miximum of 2488.9 i.h.p. at 240 r.p.m. (56 m.p.h.). (Par. 66.)

Locomotive.

14. The maximum drawbar horse-power that has been obtained was 2250.4 with a coal rate of 3.8 lb. and a steam rate of 19.8 lb. per d.h.p. hour. This maximum horse-power is over 20 per cent above that of the 89. (Par. 91.)

15. Compared with the 89 a higher drawbar pull was developed by locomotive No. 51, and this advantage was maintained from starting up to a speed of 85 m.p.h.

16. The machine and locomotive efficiencies are higher for the 51 than for the 89. Just why the machine efficiency is increased is not evident from any difference in the two locomotives. However, if the increase in machine efficiency is entirely discounted, and the efficiencies are assumed to be alike, there is still a large increase in the drawbar horse-power for the 51. The locomotive efficiency is apparently increased on account of the better boiler performance. The cylinder enlargement has proven of advantage as a means of increasing the starting power, and also in increasing the drawbar pull of all speeds.

17. For any rate that coal is fired into the boiler, the locomotive shows improvement over the 89 in delivering power, which means that the locomotive, as remodeled, per pound of coal fired at any rate, will produce more power, and this is accomplished with the attendant advantage of an increased maximum power output. (Par. 93.)

Recommendations.

1. We would recommend for this locomotive the use of an exhaust nozzle with four projections or partial bridges as shown in Fig. 21, as the free steaming shown in the tests was largely due to the use of this nozzle.

2. If further increases in efficiency are to be sought, we would recommend a trial of feed water heating devices which will not reduce the capacity of the locomotive, and the development of a practical form of superheater to furnish a nearly constant superheat at all rates of evaporation. (Par. 82.)

C. D. YOUNG,
Engineer of Tests.

Approved:

J. T. WALLIS,
General Supt. Motive Power.

The President: The Executive Committee will take cognizance of the suggestions made by Mr. Pratt that Mr. Vaughan be relieved from future work on this committee. There is another question which comes up and that is whether we shall print the Bulletin of the Pennsylvania Railroad Company in the Proceedings of this convention, in connection with the subject of superheater locomotives, if we get authority to do it.

Mr. Young (Penna. R. R.): I do not believe there will be any objection at all on the part of the Pennsylvania Railroad to the publication of this Bulletin No. 27. I am not authorized to speak officially, but I have that opinion in view of the policy which has been pursued by the company in the past. This Bulletin embodies tests of certain modifications in the Class E6 engines, covering the results of changes made in the first design, and as the results of the improvements of the engine by reason of these changes are given in this report, it therefore is practically a closed subject for this class of engine, on the effect of superheater and certain changes in boiler and cylinder design. I think there will be no trouble on that score.

The President: The next business will be the report of the Committee on Fuel Economy, Mr. William Schlafge, G. M. S., Erie R. R., is chairman.

Mr. Schlafge presented the report, as follows:

REPORT OF COMMITTEE ON FUEL ECONOMY.

To the Members:

In the further study of the subject of fuel economy, your committee has deemed it advisable to depart somewhat from the method followed in last year's report. That report was very broad in its scope, in order to cover, in a general way, all phases of the subject. Since then the committee has been made a standing one, and an effort is made this year to limit the report to the consideration of a few of the leading essentials of fuel economy, and, with the help of the discussion, they may be closed for the present, unless new developments should warrant their further study, thereby leaving the way open for taking up still other phases of the subject in subsequent papers.

1.—Design of Locomotives with Respect to Fuel Economy.

That design of a locomotive boiler and fire box, together with the appurtenances, which will permit of the largest possible amount of evaporation from a given amount of combustible burned, has the maximum

efficiency, and is, therefore, the best boiler from the standpoint of fuel economy. This statement defines an ideal for the attainment of which all should strive, and which is being approached more nearly as time goes on.

Unless a locomotive has been designed according to the best-known practices, it can not be expected to show as great economies in the use of fuel as would a locomotive which had been properly proportioned. Greater attention is being given to the design of boilers, fire boxes, grates, ash pans and front ends than ever before, as all of these parts are interdependent and should bear a definite relation for the best results, and are influenced by the nature of the fuel available.

A study of certain ratios in locomotives constructed within the past two years, and in others built ten or twelve years ago, shows the trend of locomotive design in those respects which have the greatest influence on fuel consumption and steaming capacity. The data shown below are the averages for a large number of bituminous and anthracite burning locomotives of the 4-6-2, 4-6-0, 2-8-0 and 0-6-0 types.

1.— BITUMINOUS:

Type of Locomotive.	Ratio Total Evaporative Heating Surface to Grate Area.		Ratio Fire-box Heating Surface to Total Evaporative Heating Surface.	
	1913	1903	1913	1903
4-6-2	65.9	70.9	6.4	5.4
4-6-0	52.3	62.8	7.8	6.5
2-8-0	53.3	60.1	6.7	5.7
0-6-0	53.0	71.8	8.3	6.0
Average	56.1	66.4	7.3	5.9
Per cent change	Dec. 15.5 per	cent.	Inc. 23.	7 per cent.

2.—ANTHRACITE:

4-6-0	30.0	34.8	8.0	6.5
2-8-0	31.1	37.9	8.3	6.1
Average	30.5	36.3	8.1	6.3
Per cent change	Dec. 16 per	cent.	Inc. 28.5	per cent.

The changes in these ratios are, without doubt, steps in the right direction. The reduction in the ratio of total evaporative heating surface to grate area means that to produce a given amount of evaporation less coal will have to be burned per square foot of grate area, resulting in a higher fuel efficiency, and an increased fuel capacity when it becomes necessary to force the boiler. A distinct gain in fuel efficiency is represented by the increase in the ratio of fire-box heating surface to total

evaporative heating surface, because reliable tests have demonstrated that a square foot of fire-box heating surface will evaporate about five times as much water per hour as will a square foot of tube heating surface, when the locomotive is developing its rated working power. This shows the importance of a relatively large fire-box heating surface in relation to fuel economy. The increase of nearly 24 per cent for bituminous and over 28 per cent for anthracite burning locomotives, in the ratio of fire-box heating surface to total evaporative heating surface, is a marked improvement in this direction.

The advantage of large heating surfaces and large grate area in increasing the evaporation from a unit amount of fuel consumption over that from a similar locomotive with smaller heating surfaces and grate area, is clearly shown by an evaporation test recently conducted at the Pennsylvania Railroad testing plant at Altoona, between a Consolidation type and a Mikado type locomotive. The principal dimensions of the two locomotives and a summary of the data follow:

PRINCIPAL DIMENSIONS.

ITEM.	Consolidation.	Mikado.	Per Cent Increase Favor of Mikado.
Cylinders	24 by 28 in.	27 by 30 in.	....
Drivers	62 in.	62 in.	....
Boiler pressure	205 lb.	205 lb.	....
Smallest diameter of boiler	76¾ in.	76⅝ in.	....
Length of flues and tubes	15 ft. 0 in.	19 ft. 0 in.	....
Heating surface, flues and tubes	2 841.2 sq. ft.	3 746.8 sq. ft.	....
Heating surface, superheater	1 173.3 sq. ft.	1 730.9 sq. ft.	....
Heating surface, fire-box	187.0 sq. ft.	288.6 sq. ft.	....
Heating surface, total	4 201.5 sq. ft.	5 766.3 sq. ft.	37.2
Grate area	55.1 sq. ft.	70.0 sq. ft.	27.1
Weight on drivers	219 900 lb.	235 800 lb.	....
Total weight of engine	249 599 lb.	315 600 lb.	....
Total tractive power	42 661 lb.	57 850 lb.	....

SUMMARY OF TEST DATA.

Dry Coal Fired Per Hour, Lb.	Water Evaporated, Per Hour, Lb.		Per Cent Increase Favor of Mikado.
	Consolidation.	Mikado.	
2 000	17 000	17 000	0.0
4 000	27 000	30 000	11.1
6 000	32 500	43 000	32.3
8 000	34 500	52 500	52.2

These figures clearly show the advantage of the large heating surface and large grate area, and that the economy increases with a decrease in the rate of combustion.

The above testing-plant figures are verified by the results obtained from a road test on the Chicago & North Western, reported in the *Railway Age Gazette* of January 15, 1915, pages 93-94. The locomotives compared were of the Consolidation and Mikado types, each equipped with superheater and brick arch. The principal dimensions of the two locomotives and a summary of the data follow:

PRINCIPAL DIMENSIONS.

ITEM.	Consolidation.	Mikado.	Per Cent Increase Favor of Mikado.
Cylinders	25 by 32 in.	27 by 32 in.	....
Drivers	61 in.	61 in.	....
Boiler pressure	170 lb.	170 lb.	....
Smallest diameter of boiler	81½ in.	81½ in.	....
Length of flues and tubes	15 ft. 2 in.	21 ft. 0 in.	....
Heating surface, flues and tubes	2 838.7 sq. ft.	3 937.3 sq. ft.	....
Heating surface, superheater	915 sq. ft.	1 335 sq. ft.	....
Heating surface, fire-box	186 sq. ft.	230 sq. ft.	....
Heating surface, arch tubes	28 sq. ft.	29.6 sq. ft.	....
Heating surface, total	3 967.7 sq. ft.	5 531.9 sq. ft.	39.5
Grate area	53 sq. ft.	63.1 sq. ft.	19.1
Weight on drivers	214 500 lb.	227 500 lb.	....
Total weight of engine	243 500 lb.	302 000 lb.	....
Total tractive power	47 500 lb.	55 300 lb.	....

SUMMARY OF TEST DATA.

ITEM.	Consolidation.	Mikado.	Per Cent Saving Favor of Mikado.
Tonnage handled	2 284	2 919	....
Length of run, miles	126.09	126.15	....
Running time, hr	6.15	5.87	....
Total coal burned, lb	19 728	20 656	....
Water used, lb	119 470	137 493	....
Total ton, miles	287 976	368 237	....
Coal per 1 000 ton miles, lb	68.5	56.1	18.1
Water per 1 000 ton miles, lb	415	373	10.1

From these data the advantage of the increased heating surface and larger grate area is apparent, for in the two locomotives compared all other conditions are as near the same as can be expected, and the contrast between them gives a true comparison.

Taking advantage of the opportunity afforded by locomotives with trailing trucks to increase the size of fire box and grate area over those proportions in locomotives without trailing trucks, affords a valuable means for reducing the fuel consumption on a ton-mile basis.

The design of exhaust nozzles to suit the various conditions, and as a factor in fuel economy, is very important. A number of roads have experimented with special types of nozzles, and claim a considerable saving in fuel as a result. Your committee feels that the subject presents a fertile field for future investigation, due to changed conditions since previous reports were made.

The practice regarding the amount of air opening in ash pans varies between wide limits, ranging from 3 to 18 per cent of the grate area for bituminous and from 10 to 33 per cent for anthracite locomotives. These figures include all classes of service. The difference of opinion as to the proper amount of ash-pan air opening is clearly evidenced by the above figures. The importance of air openings through the ash pan should not be overlooked, and it would be well to establish definitely the minimum opening in the ash pan as a percentage of the grate area. From the best data that the committee has been able to obtain thus far, it appears that this should not be below 12 per cent for locomotives having 70 sq. ft. of grate area, and this percentage should be increased with smaller grate areas.

In closing the subject of design of locomotives, it can be said that the tendency in proportioning locomotive parts is toward increased efficiency. The almost general application of superheaters and brick arches, not only to new locomotives, but also to many older ones, should not be lost sight of in this connection, as both are important factors in fuel economy and smoke reduction. The practice of welding flues into the back flue sheet is a step in fuel economy, because leaks in the fire box are reduced and the fire does not have to be drawn so frequently for repairs. Much has been done already, but more remains to be done, not only in perfecting new appliances, but also in improving what now exists, as, for example, feed water heaters. Care should be taken in the design of all future locomotives to have the boiler capacity at least equal to, and, if possible, somewhat in excess of, the maximum power requirements of the cylinders, in order that the expected maximum hauling capacity of the locomotives may be obtained under adverse conditions.

2.— Operation of Superheater Locomotives.

When properly maintained and efficiently operated, the superheater is by far the most valuable mechanical aid to fuel economy ever applied to locomotives. By its use savings of 20 to 25 per cent in coal and water are

obtainable in actual service. But if maintenance is neglected and careless handling of the device in service is permitted, the superheater may become almost useless, as far as performing its regular function is concerned.

It is not within our province to discuss the question of superheater maintenance in a paper of this nature, but the question of superheater operation is extremely vital to the subject of fuel economy, and should be given careful consideration.

That the method of handling the throttle on superheater locomotives is of more importance than is generally realized, has been shown by the answers given to our question as to the proper method of using the throttle on superheater locomotives. The best results are secured by the use of a full throttle opening, with reverse lever control as far as service conditions will permit, the exceptions being: When starting a train, when using a very small quantity of steam while running at high speed on low grade or level track, and when drifting. Actual test data prove conclusively that greater economy of fuel and water is obtained by operating with a full throttle opening and a short cut-off than with a partial throttle opening and a longer cut-off. The figures shown in the following table were drawn from the charts, Figs. 52 and 53, pages 100 and 101, of the Report of Tests of a Class E 6S passenger locomotive at Altoona, which forms a part of the 1913 Proceedings of this Association:

	Lb. per Indicated H.-P. Per Hour, at 1500 H.-P.			Per Cent Saving.	
	Partial Throttle.		Full Throttle.		
	1 40% Cut-Off.	2 30% Cut-Off.	3 20% Cut-Off.	3 over 1	3 over 2
Dry Coal, lb.	2.52	2.25	2.02	19.8	10.2
Steam, lb.	18.9	17.5	15.8	16.4	9.7

The committee is of the opinion that, to secure the greatest economy in the use of fuel and water, superheater locomotives (if not all locomotives) should be operated with a full throttle and reverse lever control at all times when consistent with operating conditions.

There are several conditions which will tend to reduce the amount of superheat added to the steam while passing through the superheater, some of which indicate improper inspection and maintenance, while others are within the control of the enginemen. The principal causes of loss of efficiency in the superheater are as follows:

1. When water is carried at too high a level in the boiler, priming is very apt to result. When this occurs, water is carried over into the superheater and the water has to be evaporated. The superheater then necessarily fails to perform its proper function and there is a partial or total loss of superheat until the priming ceases.

2. If the fire is in poor condition, due to improper or excessive firing, or to holes in the fuel bed, there is bound to be a drop in the temperature of the flue gas, which reduces the amount of superheat added to the steam.

3. Plugging up of superheater flues, failure of the superheater damper to work properly, or leaks in the superheater or in the front end, will impair the efficiency of the superheater.

Without a special appliance it is not easy, in fact, it is practically impossible, to judge how well the superheater is performing. The steam gage is of little, if any, value in determining how much superheat is being obtained, it being entirely possible for any of the above conditions to exist without causing a drop in boiler pressure. It would appear, therefore, that to insure obtaining the best results from the superheater, a temperature indicator is desirable.

Several roads have experimented along this line with pyrometers, the gage being located in the cab and calibrated to show temperature in degrees Fahrenheit, making it possible to tell at a glance the temperature of the superheated steam and, indirectly, the amount of superheat which is being given to the steam.

Among those who have had experience with pyrometers there is quite a difference of opinion regarding their value as an aid to the enginemen in improving locomotive operation. Of those replying to the questions relative to experience with pyrometers on superheater locomotives, fifteen have had some experience with the device. Nine replies were unfavorable to the use of the pyrometer, except perhaps for tests or for limited application for educational purposes. The other six replies were entirely favorable to the application of the pyrometer to all superheater locomotives.

One of the largest roads, operating a great many superheater locomotives, contemplates the application of the pyrometer to all these locomotives, because the mechanical and operating officers feel that it "will result in improved locomotive performance and reduced fuel consumption, through the fact that enginemen can always observe what degree of superheat they are obtaining, and thereby regulate their fire and handling of locomotive accordingly." They also add that they consider the pyrometer "would keep the enginemen more interested in their work and indicate to them promptly any irregularity in the performance of the superheater, which can be corrected, if possible."

On the road with which the Chairman of your committee is connected, some experimenting has been done with the pyrometer, both in regular road service and on tests. It was observed that the enginemen were very enthusiastic over the results obtained with the device, and, as a rule, the fireman watched the pyrometer gage much more closely than he

did the steam gage. In spite of its apparent delicacy of construction and adjustment, the instrument maintained its setting quite accurately. While we are not prepared to say that the cost of applying pyrometers generally would be justified by the savings resulting from their use, the device is not without merit, and, as an educational feature, the cost of a few applications would undoubtedly be amply repaid.

3.—Instructions for Enginemen and Firemen.

In order to obtain the best operating efficiency and the greatest amount of fuel economy, careful attention to two fundamentals is absolutely essential. The design of locomotives must be such that economy is obtainable, and the enginemen and firemen must receive suitable instruction in order that the desired economies can be realized. The most efficient locomotive, handled by men who are careless or who have not been properly instructed, will not show satisfactory service results. Of necessity, many locomotives which are not up to recognized standards of design will be in service for several years more, and, if the best all-around results are to be had, the instruction of the men who are expected to bring about economies must be given the most careful consideration.

Foregoing portions of the report cover, in a general way, those factors of locomotive design which have the greatest influence on fuel economy. Your committee now proposes a standard Manual of Instructions for Enginemen and Firemen, which will embody all the essential points of efficient locomotive operation, and will at the same time be brief and free from technical data. These instructions presuppose expert class and individual instruction, which will do more good than any amount of written instructions of a technical or detailed nature. In addition, examinations are, of course, desirable, and are recommended.

FUEL ECONOMY ON LOCOMOTIVES.

Introduction.

The object of these instructions is to bring about the economical use of fuel, to promote good practice in the operation of locomotives, and to improve the methods of firing.

As the engineman is in charge of the locomotive, his instructions must be followed, and both he and the fireman should work together to bring about the desired results. The best fireman can not make a good showing with an engineman who does not coöperate with him in the proper handling of the injector, throttle and reverse lever. The fireman is not alone responsible for the saving in coal, as a great deal depends on the engineman in his proper operation of the locomotive, and the latter should give instructions and suggestions to the fireman, based on his experience, to bring about the best results.

An efficient fireman is one having the skill and knowledge which enables him to make the fuel, supplied to the fire box, evaporate into steam as much water as possible, or, in other words, he makes the fuel perform

its full duty. There are other qualities which increase the value of a fireman, but the ability to keep up steam is the first consideration. Good judgment is an aid to success in every calling, but it seems especially essential in a fireman.

Economy in the use of fuel is required, because the fuel used on locomotives is one of the largest items of expense to all railroads. As the greatest portion of the fuel passes through the fireman's hands, he can use it economically (depending on his ability, skill and good judgment, coupled with the coöperation of the engineman in handling the locomotive), or he can waste it through lack of knowledge or inattention to his duties. Furthermore, by burning no more coal than is absolutely necessary, the labor of firing is lightened, and by taking an intelligent interest in the condition and operation of the locomotive, the fireman is a very important factor in the saving of coal and water.

By explaining to the new fireman the reasons why certain methods should be pursued in handling his work to bring about the best results, and by directing attention, if necessary, to improper methods on the part of the experienced fireman who may not use good judgment, the operation of the locomotive can be handled to the best advantage and the greatest saving of fuel effected.

Bituminous and Anthracite Coal.

1. Bituminous coals are usually composed of about 60 per cent carbon, 30 per cent gaseous or volatile matter, which burns as flame, and 10 per cent earthy matter, which remains on the grates as ash or clinker. Good anthracite coal contains about 85 per cent carbon, 5 per cent of gaseous or volatile, and 10 per cent earthy matter.

2. The burning of coal in a locomotive requires air, which must be admitted through the ash pan, grates and fire door. Smoke means imperfect combustion and waste of coal, and must be avoided as far as possible.

3. When bituminous coal is applied to the fire, the volatile or gaseous matter is expelled, and, if properly mixed with air and heated to a sufficient temperature in the fire box, the mixture will ignite, be consumed and pass from the fire box through the tubes and stack as a colorless vapor, leaving the solid matter on the grates in the form of coke, which burns more slowly. If, however, the gases are unconsumed, they will produce smoke.

4. Anthracite coal burns more slowly than bituminous, and, consequently, a larger grate area has to be provided in order that sufficient coal may be burned to give the required amount of steam. In other words, means must be provided to make a hard-coal burning locomotive of given proportions consume as much coal per hour as a bituminous burner of the same proportions; and no better way has been found than by designing this kind of a locomotive with a large fire box and a liberal grate area. Anthracite coal has to be fired to suit the size of the lumps used. If the coal is in large lumps, a heavy fire must be carried, because the lumps lie so open that the air would pass too freely through the fire if it were light.

The smaller the size of the coal the thinner the fire can be. The fire should be started considerably in advance of leaving time from the engine-house, in order that a good fire will be on the grates when the start is made with the train.

5. The method of light and level firing, outlined in the instructions which follow, applies to firing both bituminous and anthracite coal.

Inspection of the Locomotive.

6. The engineman and fireman should be on hand in ample time before departure from the engine-house, to thoroughly inspect and lubricate the locomotive, in order to make sure that it is in proper condition and fully equipped for making the run. Any matters which, in the judgment of the engineman, should receive attention before departure, must be promptly reported. The fire, grates and ash pan, as well as flue sheet, must be examined, to see that they are in suitable condition for making the run. The condition of the fire should be such that it will make steam freely from the start. The shaker rigging should be operated to see that it is in good working order. The damper rigging (where provided) should also be operated, to make sure of its condition. The ash pan and rigging should be examined, to see that the doors or slides are properly secured and in a condition to prevent hot coals dropping along the road, which are liable to start fires.

7. When locomotives are equipped with mechanically operated fire doors, grate shakers, or coal pushers, the same should be known to be in good working order before starting.

Preparation of the Fire.

8. When applying fuel in building up the fire, preparatory to starting, the blower should be used, to create the necessary draft, and the fire door should not be entirely closed between the shovelfuls of coal, but in all cases should be placed on or against the latch until the gases have been consumed, and the closing of the door will not result in the emission of heavy black smoke.

9. It is important that the grates should be clean and free from dead ashes and clinker. They should be left in a level position and secured there after each shaking, to prevent the fingers or edges of the bars being burned off. See that the foundation for a good fire is on the grates, that the fire is evenly distributed over the entire grate surface, and that the ash pan is clean. If these precautions are taken, the fire will be in condition to maintain the steam pressure during the trip.

Taking Coal and Water.

10. After taking coal at coaling stations, the coal pile should be trimmed, to insure the coal from falling off tenders while in transit, which saves coal and eliminates a danger to passing trains, trackmen, etc.

11. Coal or water must not be taken more frequently than is necessary, as it requires extra coal to again bring the train up to speed, especially if on a grade. This is a matter requiring good judgment, as it would not do to run short of coal or water before reaching the next coal chute or water tank. Where possible, take water only from tanks containing good water, and as little as possible from those containing bad water.

Making the Start.

12. The boiler must not be filled too full of water as soon as the locomotive leaves the engine-house. Leave a space so that the injector can be worked to prevent popping.

13. The lubricator should be started about fifteen minutes before leaving the terminal, and should be set to feed regularly, in order to insure lubrication of valves and cylinders at the start of the trip. Proper lubrication of the valves, cylinders and machinery helps to save fuel by reducing friction.

14. The sprinkler hose must be used frequently to keep down dust on the foot-plate and in the cab, and to wet the coal in the tender. The use of too much water on the coal should be avoided, as it has to be evaporated by the fire, and may result in the flues stopping up.

15. Care should be taken in starting train to prevent damage to draft gear and couplers. Preventing delays saves coal, and preventing damage saves repair costs.

16. Slipping of the drivers should be guarded against, as the heavy exhaust tears and upsets the fire and fuel is wasted in rebuilding it. Furthermore, slipping wears out tires and rails, and may damage the running gear.

Method of Firing.

17. A hard and fast rule covering the depth of fire at the start can not be made. Good judgment must be used, as the conditions under which the start is made, such as grade, weight of train, speed, etc., will influence to a great extent the kind of fire that is on the grates.

18. Large lumps of coal do not make a satisfactory fire, and they should be broken into pieces not larger than 3 in.

19. Always fire as light and level as possible consistent with the steam requirements, scattering the coal over parts where the bed is thinnest and the fire brightest, in order to prevent it from becoming dead in spots. Large quantities of coal placed in the fire box at one time cool down the fire, cause smoke and waste of coal; small quantities at regular intervals will keep the fire bright, reduce smoke and take less coal to keep up steam pressure, resulting in a reduction in the work of firing.

20. Very heavy firing is apt to cause leaks, and may cause fire-box sheets to crack, as the air can not pass readily through a heavy fire, and large quantities of cold air will be drawn through the fire door and the thinnest places in the fire, resulting in chilling the flues and sheets, the formation of smoke and a reduction in steam pressure.

21. The fire door should be placed on the latch, as far as possible, between each shovelful of coal, to keep down the smoke by increasing the admission of air through the door.

22. Do not put four or five shovelfuls of coal into the fire box at one time. One, or perhaps two, will give better results, and if more than one shovelful is used at one firing, they should not be put into the same spot. Fig. 1 shows how coal should be introduced into a single, and Fig. 2 a double door fire box, each successive shovelful being thrown to the points indicated by the numbers. This method of firing will tend to make the bed of fire uniform; but, of course, the judgment of the fireman must be depended upon to see that thin spots are kept covered.

23. Fig. 3 illustrates the effect of heavy firing under the floor, which lowers the temperature at that part of the fire box, since the heavy bed of coal does not allow sufficient air to pass through it to supply oxygen for proper combustion, and smoke is liable to result on account of part of the fuel gases passing away unconsumed.

24. Figs. 4 and 5 show the condition of the fire when the practice of light and level cross-firing, illustrated by Fig. 1, is followed. The bed of fuel is slightly heavier next to the sheets than on other parts of the grates. This is good practice, because there is a tendency for more air to pass up beside the sheets, which would cause thin spots to form around the edges, allowing cold air to pass up into the fire box. Maintaining a slightly thicker fire along the edges prevents this trouble.

25. Fig. 6 shows the thinning action of the draft around the edges.

26. Fig. 7 shows the effect of a temporary reduction in fire-box temperature when a shovelful of coal is introduced.

27. Fig. 8 shows the restoration of temperature before the second shovelful is introduced at another part of the fire box, as is the case in the system of light and level cross-firing.

28. Figs. 9 and 10 show the effect of spots or holes in the fire. The admission of a large volume of cold air through these spots causes a serious chilling effect.

29. Fig. 11 shows the application of a brick arch and the path of the products of combustion from the fire to the flues.

Operation of the Locomotive.

30. When the throttle is closed, before making a stop or for drifting, the blower must be used and the fire door placed on latch, and dampers (where provided) should be closed, in order to check the fire and prevent steam from blowing off. This practice, with the exception of the use of the blower, should be followed after using the scraper or slash bar, and when on sidings, in yards or at terminals.

31. Firing should be stopped long enough before steam is shut off to prevent smoke and waste of coal, and when making station stops the fire should be in such a condition that more coal need not be added until after the start is made. It is bad practice to begin firing as soon as the

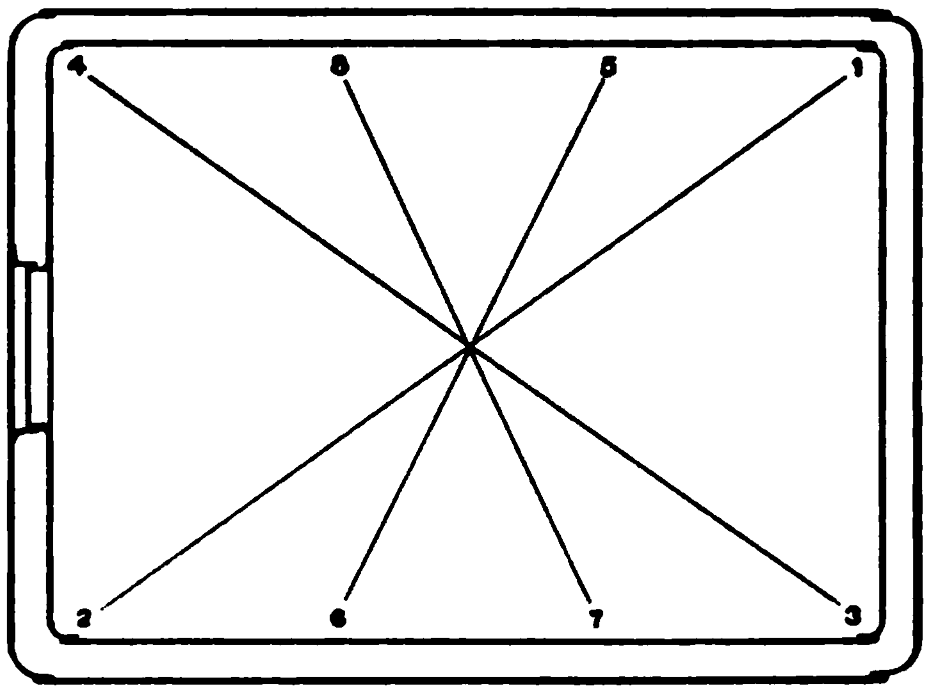


FIG. 1.

FIGURE NO.2 SHOWS THE METHOD OF CROSSFIRING A WOOTEN FIREBOX AS INDICATED BY SUCCESSIVE NUMBERS ON THE ARROWS, FIRST FIRING ON THE ONE SIDE AND THEN THE OTHER, ALONG THE WALLS AND CENTER OF THE FIREBOX.

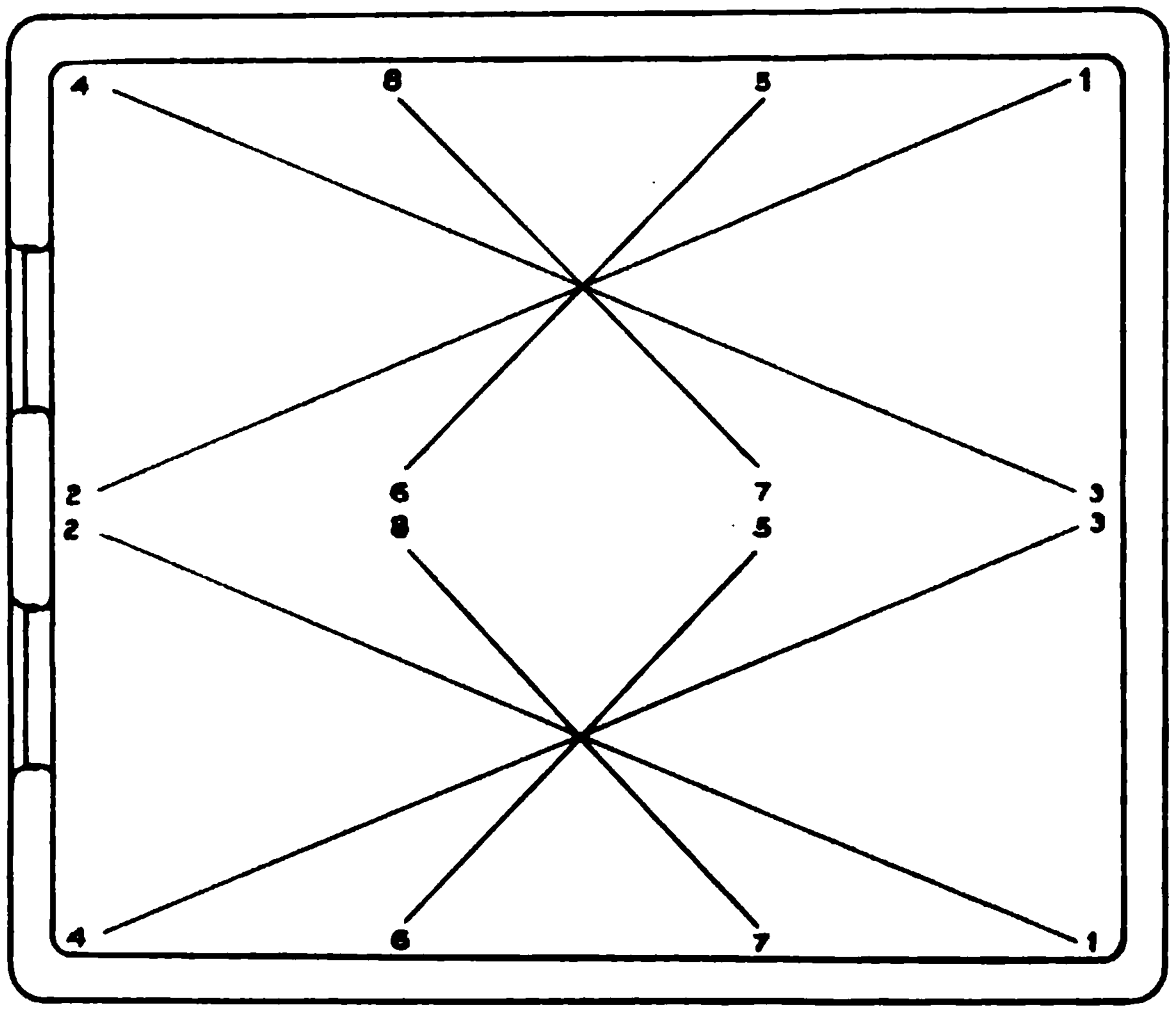


FIG. 2.

Fig. 3

Fig. 4.

Fig. 5.

Fig. 6.

Fig. 7.

Fig. 8.

Fig. 9.

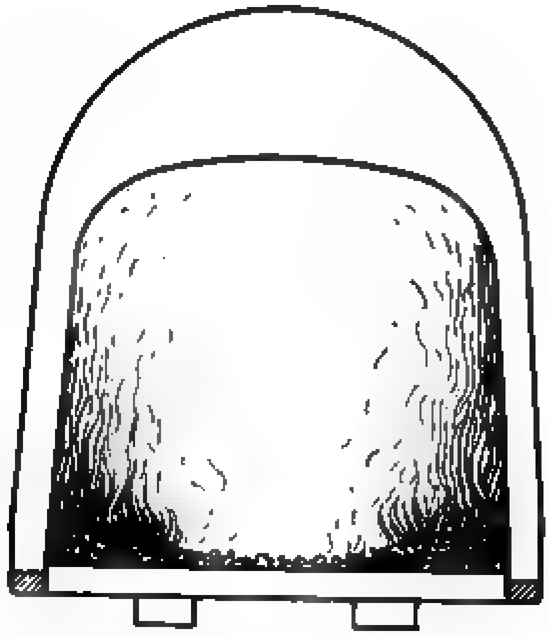


Fig. 10.

Fig. 11.

throttle is opened, because the deadening effect of the fresh coal, together with the use of large quantities of steam, will cause a reduction of steam pressure. If firing is necessary at this time, it is better to do it while standing.

32. The grates should be shaken only when necessary to clear the fire of ash and clinker in order to admit sufficient air for proper combustion, and in such a manner as to avoid the loss of good fires, which means waste of fuel. Care should be taken after each operation to place

the grates in a level position, to avoid burning the fingers, which is liable to occur if the grates are allowed to remain at an angle with the fingers projecting into the fire.

33. The waste of steam through safety valves must be avoided. Frequent blowing off of safety valves shows poor judgment, and implies that economy is not being practiced. Tests have demonstrated that about 15 lb. of coal, or one shovelful, are required to supply the steam blown off in one minute, or, in other words, if the safety valves are open for 133 min., about one ton of coal is wasted.

34. Careful attention must be given to the use of the injector and the height of the water level in the boiler. The proper handling of the injector is a very important matter in fuel economy. The best fireman can not make a showing if the engineman floods the boiler. If the injector is to be used to prevent popping, a space must be left so that the injector can be worked. The injector should be put on before, and not after, the safety valve opens. The blower should also be reduced or shut off before the steam pressure rises to the blowing-off point.

35. Coal can be saved by the proper use of the injector in feeding the locomotive regularly at a rate governed by the demands, and by taking advantage of every opportunity to increase the height of the water level when not working the locomotive to full capacity; for example, while drifting, standing in stations or switching, and permitting the level to drop slightly between stations or on hard pulls.

36. It is bad practice to start out, after making a stop, with the injectors working. The cool water introduced into the boiler while the throttle was closed starts circulating and reduces the steam pressure. If a start is made under these conditions, the steam pressure will be still further lowered and an excessive amount of firing necessitated. It is, therefore, preferable to start the injector after a train is well under way.

37. Be sure that the crown sheet is thoroughly covered with water. When ascending a grade see that the water is carried high enough so that when the locomotive reaches the top of the grade and passes on to a lower grade or a down grade, the crown sheet will be well covered.

38. The water level must never be high enough to allow water or very moist steam to be carried over the valve chambers and cylinders, because it will destroy the lubrication of these parts, and may result in serious damage, due to knocking out cylinder heads, breaking pistons or bending of main rods.

39. The engineman can save coal and greatly assist the fireman in his work by handling the throttle and reverse lever in such a manner that the minimum amount of steam will be used. The locomotive should be operated with a full throttle opening (except when starting or drifting) when the cut-off is 25 per cent of the stroke, or greater; but if 25 per cent cut-off with full throttle gives more power or speed than is needed, the

reverse lever should be left at 25 per cent cut-off and the throttle partly closed as necessary. With locomotives using superheated steam it is well to use 15 per cent cut-off instead of 25 per cent, as mentioned above.

Condition of Fire Reaching Terminal.

40. Locomotives should not be brought into terminals with a dead fire, which is liable to cause the flues to leak, nor with too heavy a fire, which will cause a waste of coal when the fire is cleaned.

Cleaning Fires.

41. When banking or cleaning fires, the blower should be used as little as possible, to avoid the rapid cooling down of the fire box and flues, which may cause leaks.

42. When cleaning fires, or with a banked fire, the excessive use of the injectors must be avoided, as this will result in injury to the flues, by the rapid reduction of the temperature of the water in the boiler producing contraction, without sufficient fire in the fire box to counteract this effect.

43. After the fire has been cleaned of ash and clinker, the clean fire must be placed at the front end of the grates (where brick arches are not used), and maintained in good condition by applying small quantities of fuel as may be required, in order to prevent cold air from passing through the front end of grate and injuring the flues. Where brick arches are used, the fire can be banked further back, as the hot arch brick protect the flues.

Final Inspection and Work Reports.

44. Great care should be exercised on the part of the engineman, on reaching the terminal, to make a thorough examination of the locomotive, and prepare an intelligent written report for the information of the engine-house foreman and those who make repairs.

45. Leaky piston and valve-stem packing, cylinder packing, or valves which cause blowing, all tend to draw on the coal pile unnecessarily, as it takes coal to generate wasted steam. This also applies to locomotive steam-heat appliances, cylinder cocks, safety valves which blow down too much steam pressure before closing, or, in other words, to all steam wasted.

46. The fireman should be consulted in regard to any defects that have come to his notice, especially with grates, grate rigging, brick arches, ash pan, firing tools, scoop rigging and dampers (where provided). Particular attention should be given to the condition of the brick arch, because this device, properly maintained, is a considerable factor in the saving of fuel and the reduction of smoke.

47. It is important that the engineman, as well as the locomotive inspectors, report all defects in a locomotive, on arrival at a terminal,

which require attention before the locomotive is again placed in service, especially as some defects can be detected to the best advantage while the locomotive is in service.

Special Instructions for the Operation of Superheater Locomotives.

48. The general operation of superheater locomotives is the same as the ordinary saturated steam locomotive. Attention is directed to a few items in connection with superheater locomotives which need careful consideration.

49. Cylinder cocks should be kept open when standing, and, as far as possible, when starting, until dry steam appears.

50. The lubricator must be started at least fifteen minutes before leaving time, in order that the valves and cylinders may be thoroughly lubricated when starting on the trip. The oil supply to the cylinders should be constant, as there is no water in the steam to assist in the lubrication, and, on this account, the superheater locomotive requires more careful lubrication for valves and cylinders than the saturated steam locomotive.

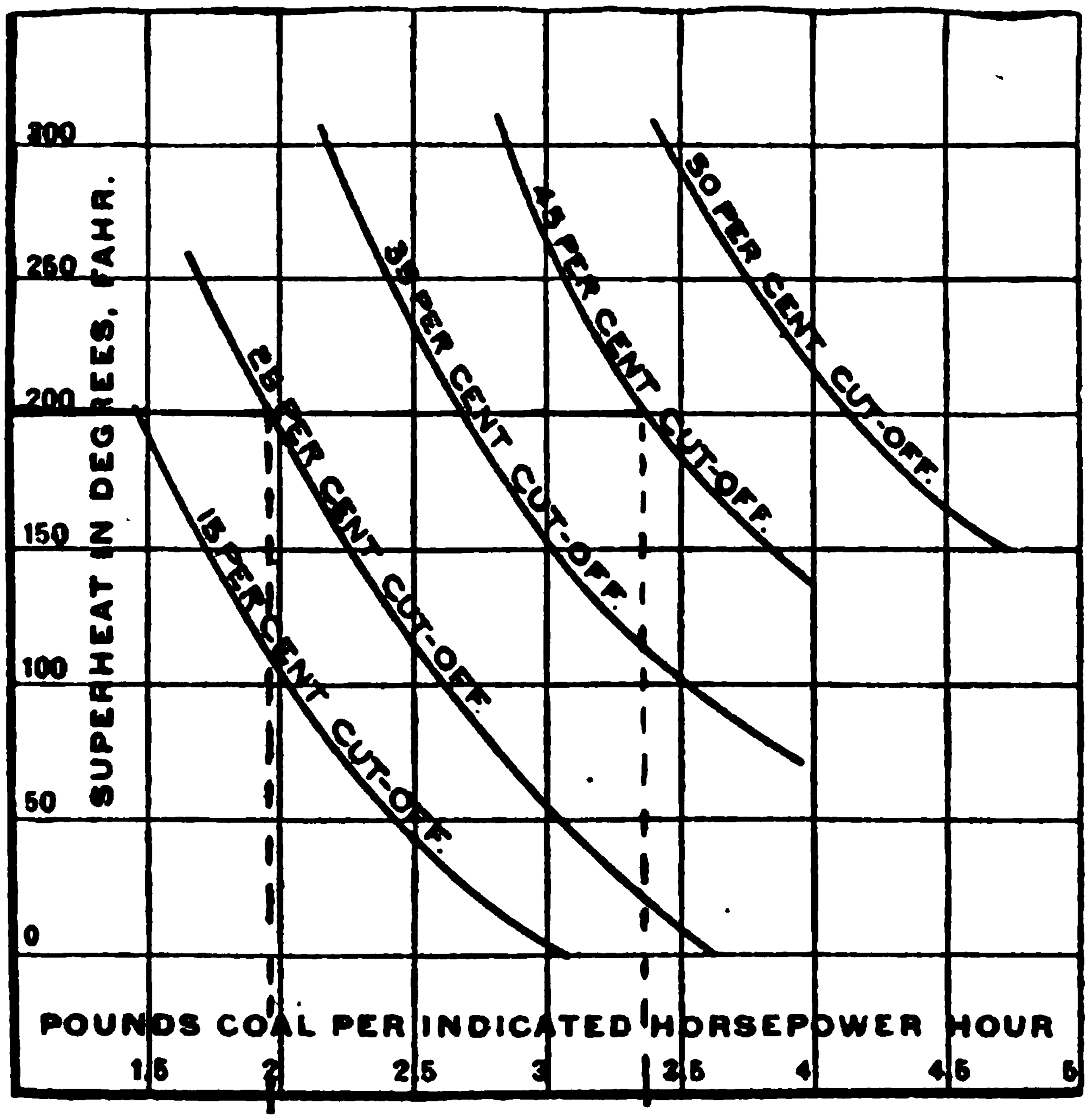
51. In starting, the reverse lever should be in full gear, to insure oil distribution to the full length of the valve bushings. Care must be taken that the water level in the boiler is not sufficiently high to cause water to carry over into the superheater, thus washing off the lubricant from the valves and cylinders.

52. Special attention must be given to the handling of the injectors, in order to prevent carrying too high a water level in the boiler. If water is carried over into the superheater while the locomotive is in operation, it will have to be evaporated in the superheater, causing a partial or total loss of superheat and decreasing the efficiency of the locomotive. Handling the water properly saves coal for the company and makes the fireman's work easier.

53. A superheater locomotive should not be moved without the required air pressure and the brakes in operative condition. When water is carried over into the superheater, part of all of it will flash into steam, even after the throttle is closed. Under the above condition the locomotive is not under control, because the valve chamber is filled with steam.

54. Superheater locomotives should be operated with a full throttle opening and reverse-lever control, as far as service conditions will permit, the exceptions being: When starting a train, when using a very small quantity of steam, and when drifting. (See paragraph 39.) The chart shown illustrates the point in question, and shows the variation in coal consumption with various degrees of superheat for each of the following cut-offs: Fifteen per cent, 25 per cent, 35 per cent, 45 per cent and 50 per cent. The figures were taken from tests of a large Pacific type locomotive, but they apply with equal force to all superheater locomotives. For example, take the curve for 25 per cent cut-off at 200 deg. of superheat. The

Variation in Coal Consumption with Varying Superheat at Different Cut-offs.



coal consumption is about 2 lb. per indicated h-p. hour. Then take the curve for 45 per cent cut-off at 200 deg. of superheat. The coal consumption is about 3.3 lb. per indicated h-p. hour. This clearly shows why it is better to operate with a full throttle and reverse-lever control rather than with a partial throttle and long cut-offs. The difference for the example taken is 1.3 lb., or 39 per cent over the incorrect method. The chart also shows the advantages of a high degree of superheat at any cut-off in reducing the coal consumption per indicated h-p. hour.

55. It is advisable, in order to avoid the suction of hot gases from the smoke box into the steam chest and cylinders, to keep the throttle slightly open when drifting or making stops, as by passing a very slight amount of steam through the cylinders, the front-end gases can not be drawn into the exhaust column. The throttle must be completely closed just before coming to a full stop.

56. The firing should be light and regular, to produce as high flame temperature and as perfect combustion as possible in the fire box. A high fire-box temperature results in high superheat, which will be obtained by a small coal consumption. A heavy, black fire means low temperature, low superheat and large coal consumption. Firemen who carefully follow the

above outlined practice will save coal for the company and make their own work easier.

57. The engineman should be sure that the superheater damper is open while using steam, and closed when steam is shut off. This can be ascertained by observing the counterweight on the right-hand side of the smoke box attached to the damper. When the counterweight is up the damper is open, and when down the damper is closed. When the locomotive is shut off and the blower is used, the engineer should observe that the damper is in a closed position. If the damper is open with the blower on, the superheater tubes are apt to be burned out, due to no steam circulating through the superheater tubes. When using steam, the piston in damper cylinder should always move its entire stroke and stop against its seat, in order to prevent loss of cylinder lubrication past the piston. A leak at this point will permit steam to escape at end of drip pipe attached to damper cylinder, and should be reported promptly.

58. Leaks in front end of superheater units, steam pipes and exhaust column, fire tubes stopped up, and derangement of draft appliances not only interfere with the proper steaming of the locomotive, but reduce the degree of superheat. Blows in cylinder and valve packing will cause scoring, due to removal of oil from the wearing surfaces. All leaks such as those mentioned above should be reported promptly by the engineman, because, if neglected, they seriously affect the economical operation of the locomotive.

While your committee recognizes that a number of books and treatises on the subject of economical use of fuel in locomotives have been written, we feel that the majority have been too lengthy, too technical and too cumbersome to be of proper use to the men concerned, especially the new firemen, who have generally lacked adequate preliminary instruction heretofore. With this end in view, we have tried to point out those cardinal features which are of vital importance to the end desired, and also for the reason that many roads have no instructions on this most important subject of fuel economy. Your committee, therefore, hopes that this subject has been treated in a manner to warrant its incorporation into the Association's recommended practices.

By treating a few fundamental subjects in considerable detail, your committee has endeavored to lay a firm foundation for an exhaustive study of fuel economy, which will be extended into the future. The advantages of designing locomotives to have the maximum efficiency, and the proper instruction of the men who operate these locomotives, have been clearly set forth.

WM. SCHLAFGE, Chairman,
W. H. FLYNN,
D. M. PERINE,
ROBERT QUAYLE,
S. G. THOMSON,
D. J. REDDING,

Committee.

The President: You have heard the report of the Committee on Fuel Economy. Unless there is objection it will be accepted and opened for discussion.

Mr. John Purcell (A. T. & S. F. Ry.): I move that the report of the committee be accepted and the subject opened for discussion.

Motion seconded and carried.

Mr. Young: It seems strange that the American Railway Master Mechanics' Association should have waited so long to have on its records so splendid a piece of work on Fuel Economy as has been prepared by this committee. I feel that the details of instructions to the new enginemen and firemen are so adequately covered that had the Association something in this form ten or fifteen years ago, it would have saved many of the railroads a lot of labor in the preparation of instructions for their men in the handling of locomotives.

It seems to me the committee has covered the ground of instructions to the road employees in a very complete and concise way. The text is prepared so that it is understandable by a man in possession of an ordinary common-school education, and with this kind of an instruction book at his disposal and the proper coaching of the Assistant Road Foreman, I see no reason why there should not a be a great gain in establishing a better understanding as to the proper firing of a locomotive.

I feel that the committee's report should really go to the Association for letter ballot for adoption as a standard, rather than as recommended practice, that is, that portion beginning with "Fuel Economy on Locomotives" on page 8, to the end. The text and character of the work of the committee certainly justifies it being accepted as the standard of the Association in view of the fact that we have no standard covering this most important subject.

It has also occurred to me that it might be well for the Executive Committee to consider the advisability of publishing this portion of the report in some small booklet form, similar to the Rules of Interchange of the Master Car Builders' Association, so that copies could be procured by the small roads who do not care to have more elaborate instruction, so that they could dis-

tribute at low cost these instructions to their road foremen and to the men.

I make a motion to the effect, if it is satisfactory to the chairman of the committee, that the latter portion of the report be submitted to letter ballot for adoption as a standard. Before doing so I would like to call attention to one or two things in the report which I believe the committee may care to consider.

In Paragraph 50 it is stated: "The lubricator must be started at least fifteen minutes before leaving time." I believe the wording should be "In the case of hydrostatic lubricators they must be started at least fifteen minutes before leaving time," because in the case of a mechanical lubricator which we are using, this rule would not be entirely correct.

MR. SCHLAFGE: That is a good point.

MR. YOUNG: In the case of diagram Fig. 1, I would suggest to the committee that the radiating lines, instead of starting from the center of the fire box, if they could be made curved lines from the fire door, would be proper, as the diagram indicates that the man is firing from the center rather than from the door. I believe it would be clearer if the lines radiated from the door.

MR. DUNHAM: I second Mr. Young's motion, but with this correction, that the motion be that the matter be submitted to letter ballot for recommended practice, for the reason that we have adopted for some years the policy that matters be adopted as recommended practice for one year, before they became standard. While I agree with him that this is a remarkably good paper, and we want to get the full benefit from it, I still believe that it should be adopted as recommended practice first.

MR. YOUNG: I will accept that, if it is necessary.

THE PRESIDENT: I also ask Mr. Young if he will amend his motion by suggesting that if the report is approved on letter ballot, that it be printed in small form, like the Rules of Interchange.

MR. YOUNG: I offered that as a suggestion for the consideration of the Executive Committee.

THE PRESIDENT: We will leave it, then, to the Executive Committee.

Mr. Young's motion, as amended, was put to vote and carried.

MR. D. J. REDDING (P. & L. E. R. R.): There is one portion of the report I would like to refer to, and that is on page 7 where the committee speaks of the use of pyrometers. I hope that the manufacturers of pyrometers may be able to bring out in the near future some pyrometer which will record its performance over the entire trip, and which will be of sufficiently rugged design that it will be satisfactory for locomotive service.

It seems to me if we could apply a recording pyrometer upon which we could depend, to each locomotive using superheat, then not only the engineer and fireman would have the benefit of the knowledge obtained from the use of a pyrometer, but also the record could be examined at the end of the trip and we would have a much better means of knowing just what went on during the trip than we now have. We can not always have a road foreman on the engine.

I also wish to refer to the point where the committee speaks of starting the lubricator at least fifteen minutes before leaving time. I think that could be made clear by saying "fifteen minutes before leaving the roundhouse." Some engineers and firemen might think that if they had to go a mile to the station, they could wait until they got to the station before starting the lubricator, and I believe it is good practice to have the lubricator in operation a sufficient length of time before moving the engine so that the oil will have reached the steam chests and lubrication will begin immediately when the throttle is opened.

MR. SCHLAFGE: With reference to the pyrometer of which Mr. Redding speaks, I believe the device will be so perfected that it will register similar to the recording gages now used on stationary boilers, giving the exact record of the superheat during the entire trip. Such a device will be entirely practicable and will tend toward greater efficiency in superheat operations.

MR. YOUNG: In connection with the recording pyrometer I will tell a little story which happened on one of our lines. We felt that it would be desirable to have a recording pyrometer, and we got one driven by a clock escapement. We put this on an engine on a passenger run, in charge of a good fireman, and

he established a certain chart, and we then took charts from some of the other firemen on the same run, and we found the average superheat was not as good as in the case of the good fireman. When attention was called to this fact they said they could do better, and they did. We took the charts off, and from our estimate of coal used, we could not see that the superheater showed any economy in coal. We then rode on one of the engines, and found what the difficulty was. We found that in order to obtain superheat on the level, and when running down hill, the engineer would put on the engine brake so as to increase the load and keep the superheat up; in other words, he was producing the chart desired, but was producing it by dragging the engine. So it would seem that if we are to use a recording pyrometer, we will also find it necessary to have an indicator on it to give information as to the operation of the air brake and perhaps the throttle position. We were very much discouraged in our experiments with the recording pyrometer for that reason.

MR. W. C. HAYES (Erie R. R.): I do not quite agree with what Mr. Young says with reference to the curved lines instead of radiating lines on the diagram Fig. 1, in this paper, and do not believe that they will be more understandable by the new fireman or by the fireman at any stage of the game than those indicated in chart No. 1. We have had a great many years' experience with that chart, both in the instruction and examinations of firemen, and we find that they are all able to understand it definitely without any assistance from radiating lines. I am quite sure that if the curved lines were substituted it would complicate matters and be no benefit to the average fireman, or the average student as a fireman. That diagram is worked out on the footboard of a locomotive by giving instructions to engineers and firemen, as to what was indicated by light, level cross firing of locomotives, and in no case was it hard to make the average fireman understand exactly what was indicated, and what was meant by that chart. If you are going to indicate it by a different form, by curved lines, then you are going to lead the fireman to study it from a different angle, and I do not think you will procure the same results that we are securing at present where that chart is used as a guide to instruct both engineers and firemen as to how an engine should be properly fired.

I hope when the matter goes before the Executive Committee they will give some consideration to that phase of the subject.

While I am on my feet another thought comes to me, and that is if you submit this to letter ballot it postpones the day of judgment, and you do not get very good results from it; a great many people will not give it any attention if action is deferred. Possibly somebody else will get up a set of instructions and send them broadcast, and these may not reach the people we are trying to reach on this subject of instructions, and possibly these instructions will conflict somewhat with the instructions going out from the American Railway Master Mechanics' Association. There are two other Associations which deal with this subject, and this also brings to mind the efficacy of dealing promptly with the recommendations of the President of this Association in his opening address about bringing the other Association under the wing of the American Railway Master Mechanics' Association, if you please, so that all work of this character can be standardized.

I will say in this connection that the Fuel Association is now working on a set of instructions as to how engines should be fired and operated. The Traveling Engineers' Association is also working along the same bent.

It seems to me, as I now remember some of the actions which pass in review before my mind, that there are conflicting situations which are arising that will be dangerous, that is, it will create confusion in the minds of the firemen you are trying to reach, and therefore I believe that this convention of the American Railway Master Mechanics' Association is as fully equipped as any body of men to act, and should act definitely upon these instructions. You only get the voice of this convention, practically, if you postpone it by sending out a letter ballot, and I believe that every man present in this room who is entitled to a vote on the subject, is able after reading the definite conclusions arrived at by the committee, to cast his vote in favor of this report, and let the work go out from this convention as the standard of the Association.

These are my reasons for objecting to Mr. Young's motion, and I believe it should be considered in that light before we take

definite action on that part of the subject. It seems to me that all the specifications included in the instructions are so well framed that we should get them into the hands of the people whom they are going to benefit and the railroad companies they are trying to serve, and do it as quickly as possible.

THE PRESIDENT: I will say for your information, Mr. Hayes, that I thoroughly agree with you all the way through, but the letter ballot will be out before the Traveling Engineers' Association meets, and in that event if the majority of the members of this Association elect to print these pamphlets, they can get them out. You also brought out clearly one idea I had in mind, and that is about these various organizations cross-firing in having different rules. I think that should be avoided.

MR. HAYES: As I understand it, if we issue a letter ballot we will not reach a decision until the next convention.

THE SECRETARY: The letter ballot will go out inside of thirty days, and the members have thirty days in which to vote. By the letter ballot all of the members will vote on the question of adoption as Recommended Practice instead of the three or four hundred here to-day, and the vote can be determined in sixty days.

MR. HAYES: Will the result be included in the Proceedings?

THE SECRETARY: This report will be included in the Proceedings of the convention, and if the recommendations are adopted they will appear in our Proceedings this year as Recommended Practice. If the Executive Committee wishes to send it out in pamphlet form it will be published inside of ninety days.

MR. HAYES: I supposed the convention was a law-making body and took precedence over everything that is embodied in our organic laws; that they could change it at any time they wanted to. If I am not correctly informed——

THE SECRETARY: That was changed last year so that we could submit any question to letter ballot.

MR. PRATT: I agree with what Mr. Hayes said in regard to this diagram, because it is nothing new. The men have all understood it, and to change it might be a questionable thing to do. Any criticism of this report would merely be repeating the words

of commendation that have been said by others, but there are one or two little suggestions I would like to bring up.

Paragraph 55, page 19, in referring to the matter of drifting does not state, which it might do, that the prevention of the admission of air to the cylinders would improve the lubrication, preventing the forming of carbons in cylinders and valve chambers, which is a strong feature in superheaters.

As to paragraph 22, I would suggest an addition to that paragraph, and make it very clear, if the committee so believe, as I do, that there should be no coal whatever put in the center of the fire box. I would like to ask Mr. Hayes, who has used these diagrams, if Fig. 9 would indicate to the average fireman that there was something wrong in the middle of the fire box, and that there should be some coal thrown over into the center of the fire box. I believe Mr. Hayes takes the stand that there should be no coal placed in the center of the fire.

Mr. Hayes: That is the theory and practice which we advocate.

Mr. Pratt: Look at Fig. 9 — what does that indicate?

Mr. Hayes: That indicates a hole in the fire, from the end view. If you get a hole in the fire, you can only see it by looking through the fire-box doors. That shows the end view. The other is a side view, which represents the same thing. I think diagrams 7 and 8 are the two diagrams that represent to the firemen the manner in which the hole may be worked into the center of the fire. I agree with you exactly that no coal, unless there is a hole in the fire, should be placed in the center of the fire box. Enough coal will roll down off the shovel, as you aim it at the different points in the fire box, sides, back end, front end, etc., so that the middle will be built up. There will be a sufficient amount of coal in the center of the fire box to prevent the possibility of a hole being worked into a fire.

Mr. Pratt: Mr. Hayes, to be strictly correct, should not Fig. 9 show that bright spot over to one side, if you are going to state in paragraph 22 that no coal should be placed in the middle of the fire box? Is it advisable to show two views in a fire box which show a hole in the fire at the center?

MR. HAYES: One is an end view and the other is a side view.

MR. PRATT: The two views locate the bare spot, and show that it is in the center?

MR. HAYES: Yes.

MR. PRATT: Why not plate it over to the side, so as to be consistent with the instructions?

MR. HAYES: Because rarely such a thing as a hole works into the side of the fire box, but it works into the center.

MR. PRATT: I merely make that as a suggestion for the committee to consider, if they wish. It is purely a technical matter.

MR. WILLIAM ELMER (Penn. R. R.): I think that is a point well taken. How can you correct a hole in the center of a fire box if you do not put coal there? The method of coaling will take care of the hole.

MR. S. G. THOMSON (P. & R. R. R.): I judge that Mr. Hayes' remarks about not putting coal in the middle of the fire box refers to a narrow fire-box engine. In the case of a wide fire-box engine, nine feet wide, and nine or ten feet long, you have to put coal in the middle. If there is a hole in the middle it has to be covered. This diagram shows where the greater quantity of coal should be placed, along the sides, and the manner in which it should be placed. The air comes in along the sides and therefore burns the coal more rapidly in that location. In the wide Wootten fire boxes, the coal does not fall as much to the center from the sides as in the narrower boxes. Consequently there is frequently a large hole found in the middle of the fire box which has to be filled in as fast as it burns out. Although the diagram does not show the feeding of coal to that point, it covers the situation; because the paragraph in connection with that figure says that this must be left to the judgment of the fireman. It gives him the method for putting in the greater portion of his coal; and then it is up to him to put the coal in the middle if it burns out there. I do not think it is correct to say that you should not put coal in the middle of the fire box.

MR. HAYES: Mr. Thomson is correct on that point, technically. The diagram intends to cover the firing of narrow fire-box

engines. Where we are called upon to give instructions in the firing of Wootten fire-box engines, we divide it into two grate areas or fire boxes. The fire box is divided into two sections, making two narrow fire boxes, and we fire one side along the side of the side sheet, and then along the center of the fire box, and dividing the grate area in the fire box, and firing it on both sides from the two doors. Where we have only one fire door, an American type of fire box, we confine ourselves to firing according to the chart, and use that method of instruction in doing so.

DR. ANGUS SINCLAIR: It has been my privilege for very many years to write instructions for firemen. I began writing these when there were no others in existence, and the firing was done in a very crude manner. I recognize the details of this report as being very familiar to me, and I think they will be very beneficial to firemen if they are carried out. The difficulty has been, in giving instructions, that they were not properly followed out, and very often there was not influence enough put on the men to have them follow out these instructions. The more this Association can do to bring the instructions in this report before the men the more benefit it will be to the railway companies.

There are one or two points in the report which seem rather curious to me. Those concerned are requested to use an open throttle when using superheated steam. That is an old subject that has been up for many years. I have argued it and argued it again with enginemen. Among the old men when I first came on the field there was the impression that it was a bad thing to use a full open throttle, because it put too much pressure on the slide valve. They nearly all advocated using a light throttle to produce a light slide valve pressure, and that that was the right way to work a locomotive. It will last much longer, they said, and the repairs will be much lighter than when the full pressure is put on the valve, and I have heard it argued over and over again that the full throttle was a bad thing for the motion of the engine. It takes a long time to get over these prejudices, but the injunctions to use a full throttle with superheated steam ought to be made just as strong with saturated steam. It is a good practice to let the full steam go into the steam chest, and any modifica-

tion of it, or anything that will make the engineman believe that it is better not to use the full throttle is injurious to the principles of working the locomotive properly.

Mr. Fry: There is one point I think might be brought out in connection with the ratios given on page 2, ratio of fire-box heating surface to grate area, and total heating surface to grate area, and that is the volume of the fire box. The value of the volume is indicated on page 9, paragraph 3, where it says, "When bituminous coal is applied to the fire the volatile or gaseous matter is expelled, and, if properly mixed with air and heated to a sufficient temperature in the fire box, the mixture will ignite." Both space and time are necessary for the ignition, and it is necessary to give proper volume as well as proper grate area.

If we analyze the figures given on page 2 we see that the fire-box heating surface per square foot of grate area, which is a rough measure of the volume of the box per square foot of grate area, was 11.3 in 1903, and was reduced to 7.7 in 1913 for the bituminous locomotives, indicating that with the increasing sizes of the locomotives it is more difficult to keep up the fire-box volume. While it has become more difficult, the fact that it is desirable to keep up the volume, I think should not be lost sight of. In the anthracite locomotive the volume is not so important, of course, because there is less gas to be consumed. The figures there show 5.75 square feet of fire box per square foot of grate area in 1903, reduced to 3.76 in 1913, a decrease of 34 per cent. That evidently points to the fact that in 1903 the anthracite burners had ample volume, and that it was not so necessary to keep so high a ratio, but I think the necessity of the fire-box volume should not be lost sight of when the grate area is being increased.

Mr. Franey: It has been my experience and my observation in firing locomotives that it is not always possible to fire by rule as indicated in Fig. 1. We know that all locomotives are not drafted alike and they do not burn their fires uniformly. The experienced fireman usually looks for the bright spot in the fire and places his shovel of coal at that point. When placing a shovel of coal he observes the fire conditions and decides where to place the next one. In following this rule he will avoid bank-

ing the fire and will avoid getting a hole in the nre. It is desirable and good practice to fire as nearly level as possible. This gives uniform resistance to the air in passing through the bed of coal. This rule, of course, will be varied to suit conditions, and the fireman will naturally shovel the most coal to that portion of the fire box that needs it.

MR. SCHLAFGE: Mr. Chairman, it was not the intention of the committee to draft hard and fast rules, because we know that would not be possible. The intention was to make the right kind of a start, and emphasis was laid on the necessity for using good judgment, which holds true with everything. Conditions must be met as they arise. I am a great believer in system, and consider that any system, even though it be poor, is better than no system at all, because it affords at least a basis for improvement.

MR. POMEROY: I would just like to ask a question: Whether bituminous coal-burning engines, equipped with a combustion chamber, whether that combustion chamber is rated as a fire-box heated surface, that would make some difference in the power of the 1913 engine as compared with that of 1903?

MR. GEORGE H. BAKER: In discussing this subject last year I referred to instances I had noticed of locomotives not having sufficient air openings in the ash pans. I am glad the committee took action on the matter. I found that the general practice throughout the country — regarding the air openings in ash pans — ranges from 3 to 18 per cent of the grate area for bituminous, and from 10 to 33 per cent for anthracite coal-burning locomotives.

The committee recommends that the minimum air admission area ought to be 12 per cent for locomotives having seventy square feet of grate area, and for those having smaller grate areas the air opening ought to be larger.

Much more attention ought to be paid to the area of the air openings in ash pans. The railroads of North America pay about $700,000 a day for the coal burned on locomotives. Most people consider coal as the only fuel burned, but in fact it is only a part of the fuel of a fire. The other part is the air, or the oxygen of the air, which of course costs nothing. That is given to us by nature free, if we will only lead it to the fire.

We close up our nozzles to make a strong draft, then we permit restricted air openings in the ash pans to keep the air out, increasing the friction of the air that goes in, and decreasing the admission of air that is so greedily needed by our fires. So I would suggest that either this or another committee make further investigation, and report at the next convention on the proper area of air openings in locomotive ash pans. I think there are millions of dollars in fuel to be saved if we will only give more air to our fires.

There are laws in some States which regulate ash-pan openings, but I believe that if the right area, a liberal area of opening for air admission, could be determined, then sufficient arguments could be presented to the state legislatures to cause them to permit the use of ash pans that would furnish freely this other valuable part of the fuel for our fires.

The committee recommends the use of a full throttle and a short cut-off in using steam while running. That is something I have been fighting for for a long time. They recommend this especially for superheated locomotives, and indicate that it is proper for all locomotives, as Dr. Sinclair said a few minutes ago.

I called attention last year to the fact that a great many locomotives have not the proper means of graduating the cut-off of steam to suit the varying character of the work that the engines must do. The committee recommends a very short cut-off, 15 per cent of the stroke, for superheated locomotives; when the work of the engines can be done by giving a liberal throttle opening. Now, 15 per cent is a very short cut-off — about four inches for a 24-inch stroke.

With ordinary reverse-lever quadrants, with the notches spaced half an inch apart, frequently the engines will not do the work properly with a very short cut-off. Then the reverse lever is advanced to the next notch, which may increase the cut-off 15 per cent, when the increase probably should only be about 5 per cent more to do the required work. Close-notched reverse-lever quadrants, at least, are what all road locomotives ought to have. The screw reversing gear, which is largely used in Europe, would be better still, if that could be put on and handled prop-

erly. I think this or some committee ought to report to the next convention on the proper means of regulating and graduating the cut-off of steam for locomotive cylinders.

Most locomotives on American railroads to-day are run cutting off at eight or ten inches — rarely less than eight inches — 33 per cent of the stroke. You can tell it while riding on any passenger train, if you will listen to the exhausts. You can tell in that way what an engineer is doing; and how rarely you ever hear one pull out of a station and begin the use of a short cut-off of five or even six inches after the train is well under way. You will hear the engine keep on "barking" away at eight or ten inches, almost invariably, on nearly all railroads.

I remember a trip I made from Philadelphia to New York on the Pennsylvania Railroad, and after the train got going twenty miles an hour you could not hear the exhaust of that engine any more. What was the engineer doing? He was using a short cut-off with a full throttle; but he was an exception. He was saving money for the company and labor for the fireman; but not many engineers follow his example.

This has always been a mooted question among locomotive engineers. The engine may ride easier, and the cab jar less, with a light throttle and a late cut-off — with less compression in the cylinders. Engineers may not care how much coal the engines burn, but it is a matter of one, two or three tons of coal a day in the usual operation of every locomotive whether it is run with as short a cut-off as practicable to do the work properly, with approximately full boiler pressure entering the cylinders — through a full open throttle to begin every stroke — or whether the engine is run with a partly open throttle and eight or ten inch cut-offs.

The committee has formulated a splendid set of instructions for firemen and engineers. Twenty-six years ago I was called upon to prepare a similar set of instructions. In the committee's proposed instructions, the scientific treatment of the subject and all technical details are cut out to make it easy for the men to understand. That is good for men of low intelligence. But I believe the railroads are paying wages sufficient to command exceptional intelligence in the men who fire and run the engines.

If instructions are going to be issued to them with the sanction of this Association — which is becoming more scientific every year, as any attendant of these conventions can see — I believe the scientific treatment of this very important subject should not be cut out.

The men should be required to know why they should do this and why they should not do that — not being told simply like laborers to do so-and-so, or not do so-and-so; and let them consider the instructions right or wrong, just as they suppose about it.

How much more willingly men obey when they know the rule is right and there is a reason for it — then they will obey it and live up to it; but when they do not know whether the rule is right or wrong, and the argument of some ignorant person prevails with them — then they may disregard the rule and do the work the wrong way, when they are away from supervision, as engineers and firemen generally are.

The reason I went into the science of the subjects in my "Instructions for Locomotive Fuel Economy" is because I believe every fireman and engineer ought to know the right and wrong ways of doing their work — and why they are right or wrong. That is from my own experience. I went through nearly five years of firing and three years of running locomotives before I knew whether it was right or wrong to continue working my injector after shutting off steam. I knew that it was right for my fireman and fuel economy to continue the injector while running down hills and into stations, and then to leave the injector off the first mile in running out of a station. But I did not know if my master mechanic would approve of this practice or censure me for it, because I did not know whether it damaged the boiler or not.

And then I learned from Tindall's "Heat as a Mode of Motion" that heat is the source of all motive power, and is that which gives force to the steam — that every increase in the pressure of steam means an increase of temperature; that a certain temperature always accompanies a certain steam pressure — and when the steam pressure varies the temperature varies.

Then I could see very plainly from those facts that I did not damage my boiler by operating the injector in the way I knew was economical of fuel, so long as I steadily maintained the steam pressure and the temperature of my boiler, because no boiler damages could result from expansion and contraction if there were none of those movements, and there could be none with a steady steam pressure and temperature. Only for this knowledge of the process of steam formation I would never have known whether my boiler-feeding practice was right or wrong.

And so it is in the generation of heat by combustion, the absorption of heat in steam formation and the expansive use of steam in the cylinders. There is a science of these matters, made up of the truths about them, ascertained by tests conducted by some of the world's greatest scholars and engineers throughout years of investigation — and every man who fires or runs a locomotive should know them well.

THE PRESIDENT: Any further discussion?

MR. DUNHAM: I move that the discussion be closed.

Motion seconded, put to vote and carried.

MR. E. W. PRATT: Mr. President, Mr. Bell, who had the next paper on the program, has kindly consented to help out the Secretary by holding it over until to-morrow, so that the chart will not look so bad, and if there are no objections, I move you that Mr. Bell's offer be accepted and that we proceed with the topical discussions.

Motion seconded, put to vote and carried.

THE PRESIDENT: If there is no objection, I think it would be well to stand adjourned until 9:30 to-morrow morning.

FRIDAY'S SESSION.

President Gaines called the meeting to order at 9:40 A.M.

THE PRESIDENT: Gentlemen, the time for opening is a little bit past, and we will now begin the meeting. The Secretary has some announcements.

The Secretary read an announcement that the Southern Railway Company invited the members to inspect the dynamometer car belonging to the Southern Railway standing on Mississippi avenue, two blocks south of the pier.

THE PRESIDENT: We will now take up the individual paper on "Variable Exhausts," by Mr. J. Snowden Bell, which was carried over from yesterday's session.

Mr. Bell presented the paper, as follows:

PAPER ON VARIABLE EXHAUSTS.

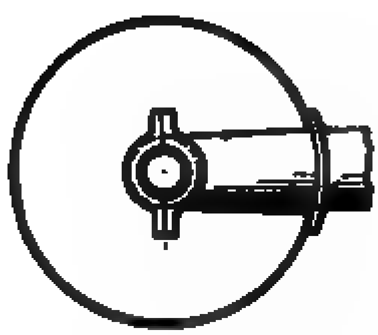
To the Members:

1. An exhaust pipe which, by discharging into the stack, tended to promote the draught on the fire, was one of the earliest features of locomotive construction, a crude form of its application having been made in England by Richard Trevethick, in his Merthyr Tydvil engine of 1803, as to which it is stated in *Nicholson's Journal* of September, 1805 (pp. 1, 2) that the exhaust steam from its single cylinder was discharged upward into the chimney, about one foot above its junction with the boiler, and that it was observed "that while the engine was at work, the fire brightened at each stroke of the piston, and the conclusion was arrived at that the draught was increased by the admission of the waste steam into the chimney." As it does not appear that a contracted nozzle was used, practically no acceleration of draught could have been effected, and mention is made of this engine merely as being the earliest recorded instance of an inside exhaust pipe.

2. There has been some controversy, the consideration of which would not be of particular interest, as to the origin of the "contracted blast pipe" or draught-inducing *exhaust nozzle* of standard modern practice, and it may, for present purposes, be assumed that this was put in actual service by Timothy Hackworth, in the locomotive Royal George of the Stockton

& Darlington Railway, in 1827. Hackworth's "blast pipe," with contracted nozzle inside of the stack, is shown in Fig. 1, which is reproduced from *The Engineer*, London, August 14, 1857. (See *Colburn's Locomotive Engineering*, London and Glasgow, 1871, pp. 20, 21.)

Fig.1.



I. Origin and Development of the Variable Exhaust.

(*a*) *Comte de Pambour's Experimental Variable Exhaust, 1836.*

3. The first recorded experimental researches on the theory and practice of the locomotive are those which were made by Comte F. M. G. de Pambour, a French engineer of marked ability, on the Liverpool & Manchester Railway, beginning in August, 1836, and continuing for several years thereafter, and among other evidences of the thoroughness of his investigations, it appears that in considering the question of the back pressure resultant on the operation of the contracted exhaust nozzle, he reached the conclusion that to properly comply with the varying conditions of locomotive operation, the *exhaust* of steam should be controlled as well as the *supply*. As a result, he was the first to propose, and to experimentally apply, an exhaust pipe having a nozzle of variable discharge area, and while he did not produce an appliance suitable for practical service, he originated the *idea* of the variable nozzle, leaving to his successors the work of its practical development.

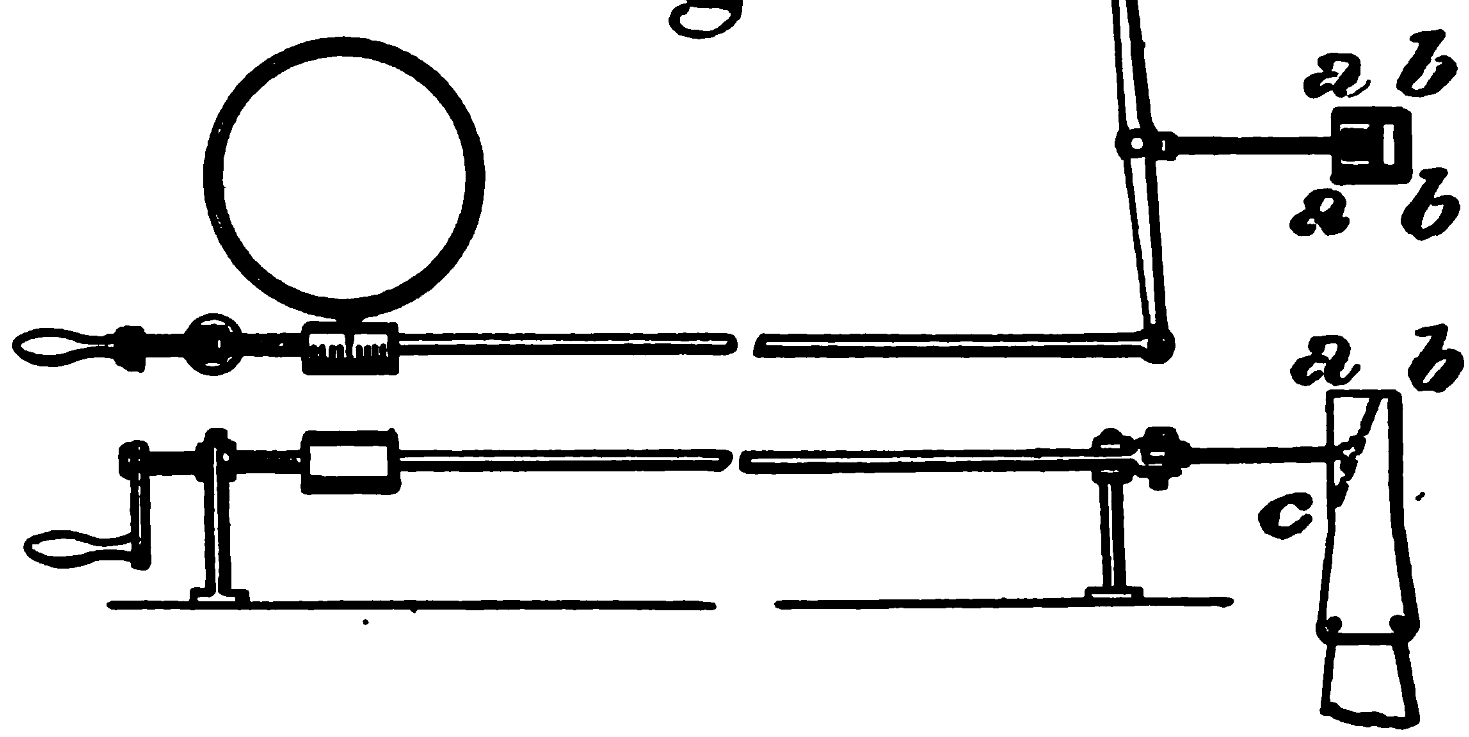
4. The principle of the variable exhaust, its origination by Comte de Pambour, and its importance, are briefly but clearly set out in the fol-

lowing excerpt from *Etude de la Locomotive, La Chaudiere,* by Deharme and Pulin, Paris, 1900, p. 157, reference being made to an earlier statement to the same effect in *Guide du Mecanicien,* by Le Chatelier, Flachat, Petiet, and Polonceau, Paris, 1859, p. 94.

> "*Variability of the Exhaust.* We have seen that, upon the theory of Zeuner, verified by practice, the weight of air drawn by the jet of exhaust steam increases, when, all things being equal, the section of the discharge orifice diminishes. Such is the principle of the *variable exhaust,* and one of the important improvements introduced in the construction of locomotives has consisted in the application of it which was made, in the first place, by M. de Pambour, in 1836, on the Liverpool & Manchester Railway, with the object of measuring the influence of the exhaust pipe on the back pressure of the steam behind the pistons. M. de Pambour immediately advised the employment of this system in the regular service of locomotives. Toward the year 1842 the variable exhaust was applied on the railroads of Alsace, following which it was promptly extended over the greater part of the other French railroads."

5. The experimental, or, as he termed it, "factitious" variable exhaust of Comte de Pambour is shown in Fig. 2, which is reproduced from the sec-

Fig. 2.



ond edition of his *Practical Treatise on Locomotive Engines,* London, 1840. As described by him, the upper part of the exhaust pipe of the locomotive "Star," of the Liverpool & Manchester Railway, was cut off, and a "bonnet" substituted, the lower end of which was bolted to the exhaust pipe, and the upper portion shaped into a quadrangular conduit, *a a b b,* each side of which measured 2½ in. in width on the inside. Three sides of this conduit were fixed, and the fourth movable on a hinge *c,* by a rod operated by the engineman. The description states that

"when this factitious blast-pipe was entirely open, it presented a square orifice whose side was 2.5 in., that is to say, an area of 6.25 sq. in.; and when the movable side was forced into the opening 1½ in., the efflux orifice was no more than 2.5 in. by 1 in., that is to say, was reduced to 2.5 sq. in. of area. By this means, then, the orifice of the blast-pipe could be altered at pleasure."

6. A record of experiments which were made with this experimental apparatus by Comte de Pambour on August 9, 10 and 13, 1836, will be found in the table on page 193 of his "Treatise," referring to which he concludes his consideration of this subject with the following recommendation, which, as will hereafter appear, was put in practice at an earlier date than that given by the French authors previously mentioned.

"It will there be recognized how, by augmenting the orifice of the blast-pipe, the resistance against the piston, arising from that cause, may be diminished at pleasure; and it may probably be found, in consequence, that in the regular work of locomotives, it might be useful to adopt a blast-pipe with a variable orifice, such as we employed temporarily in our experiments. Then, by contracting the orifice of efflux of the steam only just as much as is necessary, there will be no more resistance against the piston than what is indispensable for the proper action of the engine."

(*b*) *Ross Winans' Variable Exhaust, 1840.*

7. Ross Winans, of Baltimore, Md., took up the design and construction of locomotives contemporaneously with their introduction into this country, and from 1843 to 1860 was one of the most prominent locomotive builders of the United States. He has appropriately been characterized as "one of the strongly marked men of his generation," and as having "peculiar traits which would have made him a conspicuous character no matter what calling he had chosen." His mechanical skill and ability were manifested by numerous improvements which he invented and introduced, and while, as has been shown, the *theory* of the variable exhaust and an experimental, though impractical, appliance for its application were originated by Comte de Pambour in 1836 and published in 1840, Mr. Winans is, so far as shown by the records available to the writer, entitled to the credit of the design and production of the first construction by which Pambour's experimental appliance was brought to a form which was capable of practical and effective operation in regular locomotive service.

8. The Winans variable exhaust, as originally designed and as extensively applied both in this country and in Europe, was of very simple construction, and consisted in a conical plug, fitted to be raised and lowered inside of the exhaust nozzle by the engineman, so as to correspondingly diminish or increase the area of the surrounding annular orifice through which the exhaust steam was discharged, and is shown in U. S. Patent No.

1868, granted to Ross Winans on November 26, 1840, for "Mode of Regulating the Waste Steam in Locomotive Steam Engines."

Fig. 3, which is reproduced from the patent, illustrates its application with double nozzles, but it was generally applied with a single nozzle.

Patent No. 1868 was extended for seven years from November 26, 1854, and was doubtless profitable to Mr. Winans, as the design was adopted by other builders, and in litigation the claim was sustained. It was a very broad claim, being

> "The plan of increasing or diminishing the force with which the steam from the cylinders enters the chimney, at the pleasure of the engineman, while the engine is in use or motion, by enlarging or contracting the orifices of the escape pipes, increasing or diminishing thereby, at pleasure, the draft of the chimney, in the manner above set forth; not intending by this claim to limit myself to the precise arrangement of the respective parts as herein described, but to vary the same as I may think proper, while I attain the same end by means substantially the same."

9. The application for Patent No. 1868 was filed October 10, 1840, and as various other improvements made from time to time by Mr. Winans were put into service before applying for patents for them, the writer believes that he followed the same course with his variable exhaust. It is also practically certain that he first applied it on the Baltimore & Ohio R. R., but by reason of the destruction of old files and drawings by fire and an ill-judged order of a former official, it has been impossible to develop any record of the dates on which locomotives of the B. & O. R. R. were first and afterwards equipped, or of the exact form of its early applications on that road. The earliest illustration of an operative design of the Winans variable exhaust which has been found by the writer is that which appears in the drawings of the locomotive "Philadelphia," built at the Reading shops of the Philadelphia & Reading R. R. by James Milholland, Master of Machinery, and put in service in April, 1847.

This design is shown in Figs. 4 and 5, which have been prepared from the very complete drawings of this engine appearing in *American Locomotives*, by E. Reuter, New York, 1849, and will be self-explanatory. It may be also noted that they show an early application of the present standard form of locomotive throttle valve.

Fig. 4.

10. The use of variable exhausts of the Winans movable cone plug type was continued on the Philadelphia & Reading R. R. up to about the year 1900, since which they have been replaced by the plain fixed type.

The latest design which was in service on that road is shown in Fig. 6, reproduced from the company's Drawing 1202, and Mr. S. G. Thomson, Supt. M. P. and R. E., through whose courtesy a print of it was furnished to the writer, says regarding it:

> "Drawing 1202 shows a practical, efficient design which was applied on a number of passenger and freight engines, giving excellent service and showing considerable saving in fuel, when properly used by the enginemen."

(*c*) *Polonceau's Variable Exhaust, 1842-1847.*

11. The practical development of Comte de Pambour's experimental variable exhaust which next succeeded the Winans design appears to have been that adopted on the Alsatian Railways, the date of which is, as before stated, given by French authors as being in 1842. The writer has been unable to find any description or illustration of the construction applied, although it is referred to in *Organ fur Eisenbahnwesen*, Vol. 2, Wiesbaden,

1847, as "the old, simple apparatus, namely, an adjustable conical plug at the mouth of the exhaust blast pipe or a damper inside the same." Reference is made in this publication to the operative defect of the apparatus, in giving the exhaust jet an "oblique" direction, from which it is natural to conclude that it must have been of the "damper" type, that is, like Comte de Pambour's, in which only one side of the nozzle was adjustable, as this objection would not obtain if a central conical plug had been used.

12. The publication last mentioned goes on to state that, to avoid the obliquely directed exhaust jet, the constructors were led to give the exhaust jet a central direction relatively to the stack, with all degrees of opening, by making two opposite sides of the nozzle simultaneously movable. This arrangement, which was designed by Camille Polonceau, a French engineer who was prominent in locomotive improvement, is shown in Figs. 7, 8 and 9, which are so plain as to hardly need explanation.

Fig. 7.

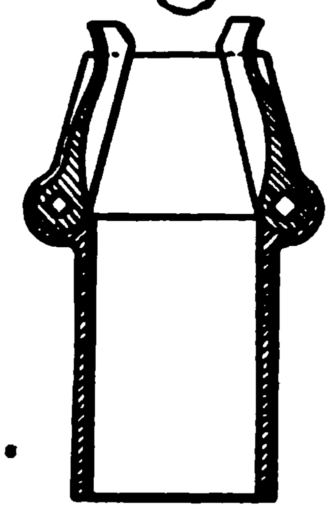


Fig. 8.

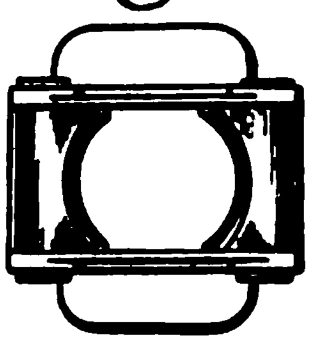
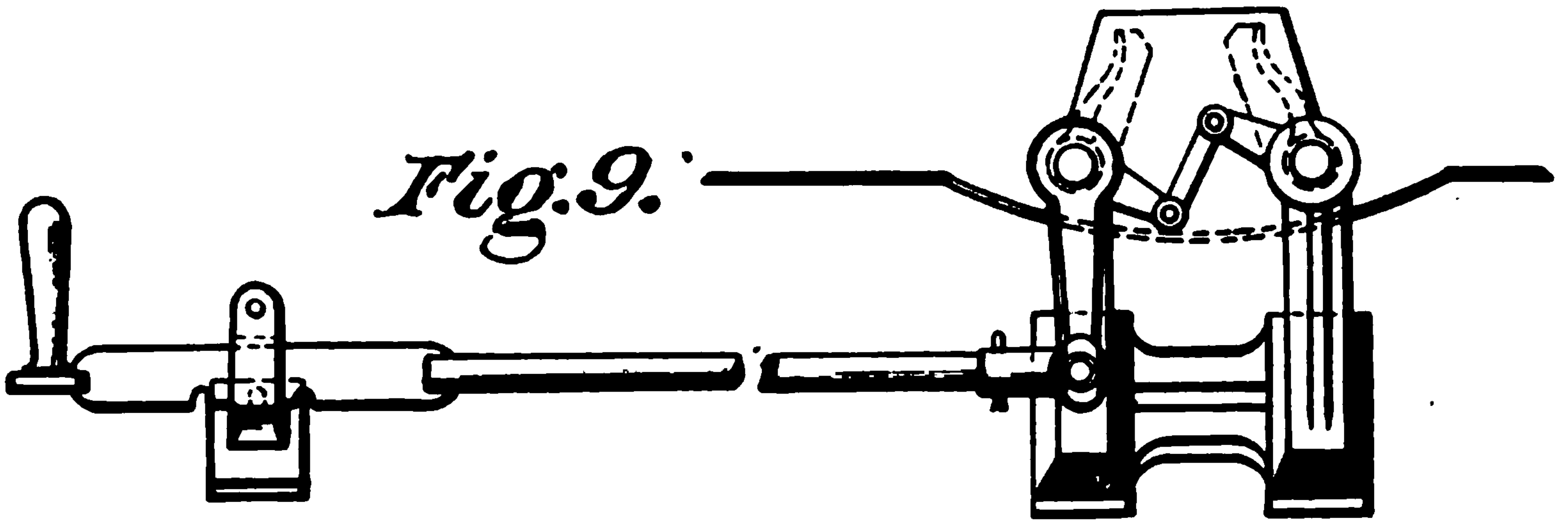


Fig. 9.



Polonceau's design, the date of which may be assumed to be between 1842 and 1847, continued to be the standard on many of the French railroads up to a comparatively recent date. It was termed the "valved exhaust" (*echappement a valves*) and is illustrated in *La Machine Locomotive*, by E. Sauvage, Paris, 1908, p. 59. At that late date, it is referred to by Mr. Sauvage as "the valved exhaust generally employed in France."

(*d*) *Ross Winans' Variable Exhaust, 1847.*

13. A form of variable exhaust which was applied by Ross Winans to engines built by him in and about 1847, and which is the subject of his U. S. Patent No. 5056, dated April 10, 1847, is shown in Fig. 10, which was made from one of the illustrations of the engine "Delaware," built by Mr. Winans for the Philadelphia & Reading R. R., appearing in *American Locomotives.*

The exhaust pipes were, in this design, connected to the bottom of a box, in the form of a frustrum of a square pyramid, and communicated with openings in the bottom of the box. Two vertical plates were fitted in the box, on stems which projected through its sides, and which could be moved toward and from each other, to decrease or increase the area of the passage between them for the exhaust steam, by a cross shaft carrying

worms or screws which engaged nuts on the stems of the plates, and which was rotated from the cab, through a pair of bevel gears. It will be seen that this construction was one which probably gave good ground for the objection urged against almost all varieties of variable exhaust mechanism, and which appears to have been sufficient to effect their disuse, namely, liability of the moving parts to become stuck fast in any adjusted position by the heat of the smoke box and action of oil and cinders.

(*e*) *E. R. Addison's Variable Exhaust, 1857.*

14. E. R. Addison, who had been a foreman in Ross Winans' shops, and subsequently master mechanic at the Mount Clare shops of the Baltimore & Ohio R. R., designed a variable exhaust mechanism, which was used on locomoties of that road about 1857.

As shown in Fig. 11, which is taken from Mr. Addison's U. S. Patent No. 18373, dated October 13, 1857, this consisted of a circular casting, journaled on a pin in a casing surrounding the exhaust nozzle, and having a number of vertical passages of different sizes extending through it, any one of which could be brought into communication with the exhaust pipe, as desired, by rotating the casting on the pin. The rim of the casting was toothed, and geared into a pinion on an upright shaft, which, through bevel gearing, could be rotated by the engineman from the cab. The Addison variable exhaust is similar in principle to those of F. Espenshade (U. S. Patent No. 10634, March 14, 1854); J. Patrick (U. S. Patent No. 22820, February 1, 1859), and W. S. G. Baker (U. S. Patent No. 23999, May 17, 1859). Patrick's design is stated, in a publication of 1861, to have been put in service on the New York Central, Erie, and some other Western lines, and Baker's was used on the Illinois Central.

(*f*) *Parrott & Head's Variable Exhaust, 1859.*

15. A variable exhaust of different type from those before described, which was brought out by Parrott & Head, and patented by them February 1, 1859, No. 22819, is stated to have been "on trial on various New England lines" soon thereafter.

As shown in Fig. 12, the nozzle is formed of a set of converging staves, *e e,* of thin metal, which overlap each other and are compressed to reduce the diameter of the outlet by thrusting pieces, *c c,* which are driven toward the center by curved wedges on a cap which is rotatable by the engineman. The elasticity of the staves increases the diameter of the outlet when the contracting pressure is released, and the shape of the outlet is practically circular, whatever its diameter may be.

(*g*) *Adams & Macallan Variable Exhaust, 1888.*

16. Another type of variable exhaust, which is shown in Fig. 13, is that of C. Adams and G. Macallan, of London, England, which was patented

Fig. 12.

F

in Great Britain by Patent No. 17014 of 1888, and in the United States by Patent No. 453,321, June 2, 1891.

It is of very simple construction, consisting of an inwardly tapering nozzle, hinged to the top of the exhaust pipe, the opening of the latter being of the largest diameter desired, while the cap tapers from this diameter at bottom to the smallest desired at its top. The cap is swung into and out of position on the exhaust pipe by connections to a lever operated by the engineman. It will be seen that this design, which does not appear to have been applied in the United States, provides only two adjustments of the discharge outlet, that is, a maximum and a minimum.

(*h*) *H. O. Olsen Variable Exhaust, 1901.*

17. This design is different in principle from any of those before described, consisting of two flexible "adjusting plates," the lower ends of which are fixed to a bridge piece in the exhaust nozzle, and which are spread outwardly, to reduce the discharge outlet, by an interposed transverse shaft, which is flattened centrally and operated by a rod. The plates are returned to their normal position, in which the maximum discharge outlet is given, by their own elasticity.

This variable exhaust, which is the subject of United States Patent No. 667,565, dated February 5, 1901, to H. O. Olsen, is shown in Fig. 14.

which is reproduced from a blue-print furnished by Mr. H. H. Vaughan, Assistant to Vice-President, Canadian Pacific Ry., on which road it was applied, as well as on the Duluth & Iron Range R. R. In the construction shown, the discharge outlet is variable between a maximum area corresponding to a diameter of 6 in., and a minimum area corresponding to a diameter of 4½ in.

18. With reference to the performance of the Olsen variable exhaust on the Canadian Pacific Ry., Mr. H. H. Vaughan advises as follows:

> "We have removed this device, as our experience was that with the superheater locomotives the exhaust nozzle was not necessary, as there was very little advantage from its use. The only engines we have used it on to any extent was on our Mallet engines, on which it is not necessary when in pusher service, but is useful for road service, as in pusher work the nozzle on the Mallet engines can be opened out to advantage when an engine is running on the level; at least that is our experience."

19. Mr. B. R. Moore, Superintendent Motive Power, Duluth & Iron Range R. R., refers to the use of this and other variable exhaust designs on that road in the following statement:

> "Between the years 1901 and 1908 there were three types of variable exhaust nozzles tested on the line of this road — the Whalen device, the Wallace & Kellogg device, and the Olsen variable exhaust. Not being on the road at the time these experiments were made, and with no records to guide me, I can only advise from hearsay that none of the results obtained warranted their continued use, and none are now in operation on the road."

(i) Wallace & Kellogg Variable Exhaust, 1903.

20. This design, which was patented by I. F. Wallace and W. L. Kellogg, January 20, 1903, No. 718,681, is similar in general principle to that of Polonceau, described in paragraph 12, and is shown in Fig. 15.

The front and rear sides or "doors" of the exhaust nozzle are hinged to it at their lower ends, and are simultaneously moved toward and from each other, to diminish or increase the area of discharge outlet, by a double grooved cam, which is rocked by an arm connected to the reverse lever. The grooves of the cam engage pins on the hinged "doors." This design was applied on the Pere Marquette and Duluth & Iron Range Railroads, and Mr. W. L. Kellogg reports that it was used for several years with very good results, and that tests with a dynamometer car proved that by its use the efficiency of the engine was increased and material saving in coal effected.

(j) Baker Variable Exhaust, 1912.

21. Another variation of structure, which appears in the patent of C. W. Baker, No. 1,042,070, October 22, 1912, is shown in Fig. 16, from

Fig.

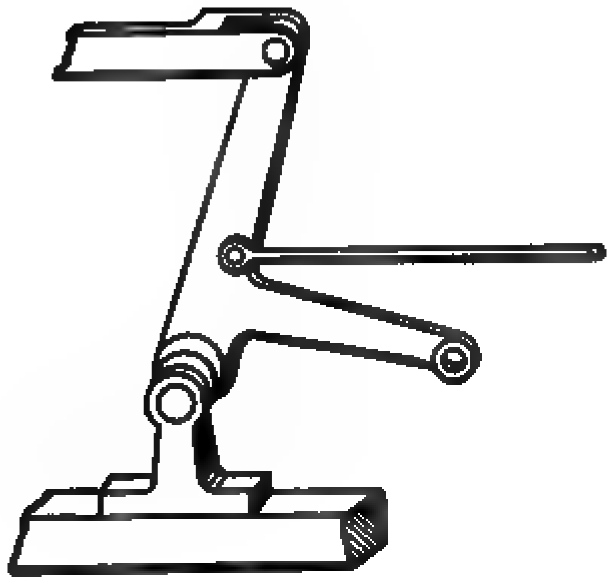
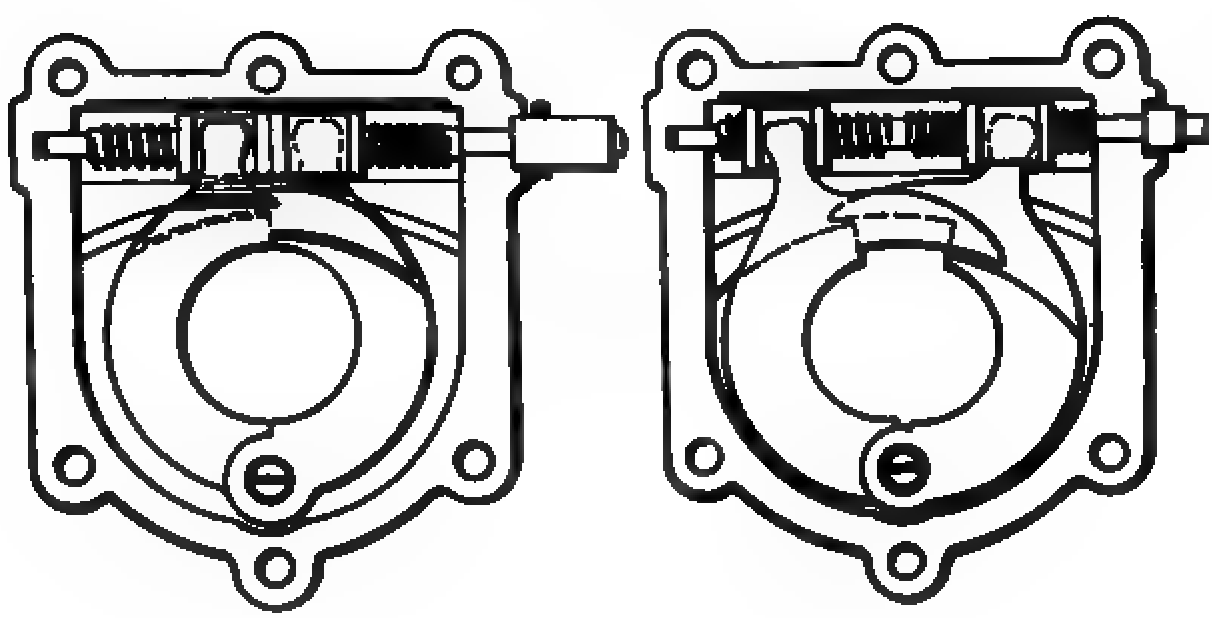


Fig. 16.



which it will be seen that the design consists of two co-acting "nozzle gates" or valves, which are pivoted to the top of the nozzle and are swung horizontally toward and from each other, with a consequent decrease or increase of discharge outlet area, by a transverse shaft, having right and left hand threads engaging threaded sleeves coupled to the nozzle gates. This variable exhaust was applied and used for about a year and a half on the St. Joseph & Grand Island Ry., with the result which is stated as follows by Mr. C. E. Slayton, Assistant Superintendent:

> "The adjustable feature worked well, that is, we were able to keep it in working order without any trouble. It was handled by a crank in the cab, which connected to a rod running along the side of the boiler to the smoke box, and there connected by a bevel-gear to a rod which operated the variable feature of the nozzle tip. There is also an indicator in the cab which indicated the size of the opening. I was very much disappointed, however, in results obtained from these exhausts. I was very much in hopes that it would show considerable saving, but they did not effect saving enough to warrant us in applying them to more locomotives."

22. The data furnished to the writer by motive power officers to whom inquiries were addressed, and an examination of some 132 United States and 58 British patents, and a number of treatises on the locomotive of dates running from 1835 to 1912, indicate that the designs that have been described include practically all the different types of variable exhausts that have been proposed or experimented with in the United States or abroad up to the present time, except one which is in use on the continent of Europe, and which will be later referred to, namely, that in which a tubular member is adjustable vertically inside a fixed nozzle. Exhaust apparatus of the type having means for enabling a portion of the exhaust steam to be discharged into the atmosphere through an independent pipe exterior to the stack, when it is desired to reduce the draught on the fire, as exemplified in the U. S. patents of H. H. Huff, No. 652,963, July 3, 1900; W. H. Prendergast, No. 654,074, July 17, 1900; and F. O. Whalen, No. 741,859, October 20, 1902, has also been tested in service, but does not appear to have made any substantial record or met with decided approval. It has not been illustrated herein, as it is not considered by the writer to be a "variable exhaust" within the general understanding of that term, that is, an appliance for varying the discharge outlet of the nozzle of the ordinary exhaust pipe.

23. As was early recognized, and as is familiar to all who have had experience with variable exhausts, the greatest objection that has been developed in their operation is their liability to become gummed up and stuck fast by the action of foreign matter and the heat of the smoke box, unless frequently moved from one adjusted position to another, and if manually adjustable, such movement is liable to be, and generally has been, neglected. To overcome this objection, automatically adjustable appliances have been proposed, the earliest, and a very ingenious example of which,

was designed by the late Mr. John E. Wootten, of the Philadelphia & Reading R. R. In this design, which is the subject of patent No. 12,805, issued to Mr. Wootten on May 1, 1855, a tube or sleeve was automatically raised and lowered from and toward a fixed central cone or plug, in accordance with variations of steam pressure, by connection to the piston of a steam cylinder, subject on opposite sides to boiler pressure and to exhaust steam pressure, and to a spring acting in opposite direction to the piston. The design, while ingenious and based on an entirely correct operative principle, was rather complicated in structure, and does not appear to have gone into practical service, although, in modified form, it has been made the subject of later patents.

24. The actuation of the adjustable member or members of a variable exhaust appliance by connection to the reverse lever has also been proposed for the purpose of preventing the parts from being allowed to become stuck by remaining continuously in one position through neglect of the engineman, the Wallace & Kellogg appliance before described being an instance. The first arrangement of this character is believed to be that shown in the patent of J. P. Clark, No. 197,720, dated December 4, 1877, in which it is broadly claimed, the first claim being for "A variable exhaust mechanism connected with and operated by the reverse lever shaft of the locomotive." While appliances of this character have been termed "automatic," they are not properly so called, because being manually, and not automatically, operable.

II. Present Status of the Variable Exhaust.

25. The replies received by the writer to letters of inquiry addressed to motive power officers of practically all the railroads of the United States, as well as reports made in technical publications, indicate that, while a number of the variable exhaust appliances before noted have been experimented with, and have, in some cases, been found to effect an economy in fuel, none of them has been considered to be sufficiently satisfactory or desirable to be retained in use, and it is not believed that any appliance for varying the discharge outlet of a locomotive exhaust nozzle is, at the present time, in railroad service in the United States. The case is, however, different in Europe, where the early introduction of the variable exhaust has been followed by its general application, and it is understood by the writer to be standard to-day in the practice of leading French railroad systems, and probably also in other countries of Europe. A description and illustration of the latest type used on the Chemin de Fer du Nord, of France, have been furnished by Mr. Geo. Asselin, Chief Engineer of that road, and the following translation of the "Note" accompanying his letter of transmission, No. 5609, November 25, 1914, is presented as representative of the most approved design of present European practice.

"Note on the Circular Variable Exhaust of the Company du Nord.

The difficulty of obtaining, with the valved exhaust (Fig. 1), a jet of steam concentric with and directed toward the axis of the stack, has led the Company du Nord, in 1904, to seek the dispositions which it should adopt to avoid the choking of steam and to augment the useful effect of the exhaust jet.

A primary modification related to the diameter of the stack, which was reduced from 450 to 380 millimeters, by the application of a false interior stack (dotted indication of Fig. 1).

The draught of the locomotive, which was already very satisfactory, was not found to be increased; it was then necessary to seek to modify the form of the exhaust itself.

We have, therefore, designed a new apparatus (Fig. 2), adopted in view of very easy detachment; presenting only centered pieces finished in a lathe; capable of accurate and permanent assembly, and delivering a constantly circular jet of steam. It has been first applied, by way of test, on a compound Atlantic type locomotive.

[Note.— M. Asselin's Figs. 1 and 2 are reproduced as Fig. 17.]

The plan view (Fig. 3) shows the final arrangement at which we have stopped. The contraction of the exhaust is regulated by the height of the interior movable nozzle. The latter is controlled by a forged finger on the exhaust moving shaft, which extends across the smoke box in the ordinary manner.

The engineman operates the movement by means of a hand-wheel and a screw; he has in sight a graduated scale which indicates to him the degree of contraction.

From the point of view of ease of taking down and cleaning of the different parts, and of their perfect centering, this head has given entire satisfaction; but it was necessary to study the result as a draught apparatus, by experimentally verifying its proportions and its forms.

Practical tests, extending through many months, were undertaken on this subject. They have been carried out upon the same locomotive, operated by the same crew, and always hauling the same train, giving the regular duty of 285 tons hauled.

With this train a speed of 120 kilometers per hour was maintained on a level track. At the same points of the run there was noted the pressure in the exhaust column, the smoke-box vacuum, the conditions of movement, and those of the steaming of the boiler.

The elements of the exhaust head, diameter of the fixed tube, and the forms and lines of the movable tube have been successively modified.

Primarily the fixed tube had a diameter of 200 millimeters; experiment showed that it was desirable to reduce it to 180 millimeters (Fig. 2). Then, while originally the minimum section of the movable tube had been placed at the upper part of the piece, this section has been lowered toward the middle of the height. It is in the final disposition (Fig. 2

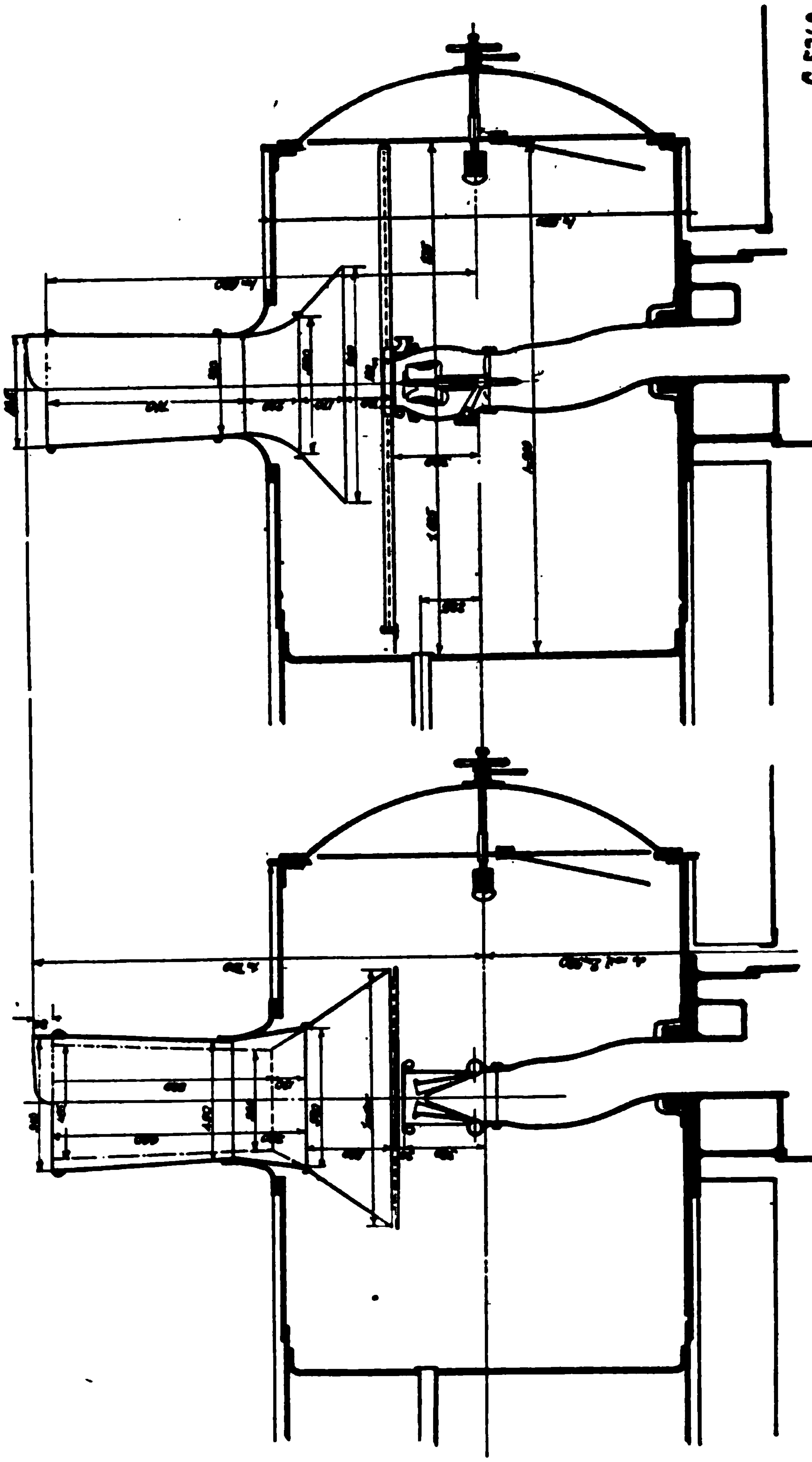


Fig. 17.

Fig. I Disposition primitive

Fig. II Disposition nouvelle

G 5763

and plan No. 3), preceded by a converging nozzle, turned and perfectly smoothed, and followed by a diverging nozzle furnished with three wings.

[NOTE.— M. Asselin's plan No. 3 is reproduced as Fig. 18.]

The form of these wings constitutes the most interesting part of the apparatus. At first, vertical throughout their height, these wings have been inflected at their upper portions, following a helicoidal surface, the pitch of which is about 1 meter.

This last modification has been recognized to be necessary following ascertainments made in service.

When the exhaust is contracted, whether the head be valved or circular, the effect is that the jet, while increasing in speed, is reduced more and more, and, therefore, fills the stack less and less.

It was, therefore, thought that it would be possible to avoid this imperfection by imparting a movement of rotation to the exhaust jet, in order to maintain the same degree of efficiency, whatever may be the degree of contraction of the exhaust. This end has been attained by the helicoidal wings.

As a matter of fact, the exhaust jet expands as much more as the section of the exhaust head is more reduced, and, consequently, as the speed of the steam is greater. It follows that the gaseous column always completely fills the stack.

Furthermore, this movement of rotation, due to the wings, augments the intimacy of the mixture of steam and hot gases, and communicates to it a greater quantity of live force. It has also been immediately recognized that, with equal section of passage of the steam in the exhaust head, the draught was noticeably increased by this last arrangement.

This result is as much more valuable for the reason that, in the high-speed compound locomotives, all back pressure resulting from the contraction of the exhaust tends to immediately create an important negative work, by reason of the large dimensions of the low-pressure cylinders and the rapidity of translation of the pistons.

The tests have shown that there exists a relation between the dimensions of the stack and those of the exhaust head, which vary, further, with the type of locomotive; they can be deduced from the annexed formulas (Table No. 4), established upon the results of our experiments.

The application of these formulas to our "Ten-Wheel" and "Pacific" locomotives has confirmed their exactness.

The character of the steam equally plays an important part in the question of the exhaust, and from the first application of superheating on the "Atlantic" engines it has been recognized that it was necessary to choke the exhaust much more (nearly 15 per cent) to obtain the same useful effect.

This new exhaust, giving at the same time a more intense vaporization and less back pressure, permits us to attain higher speeds by providing more facility for the management of the fire, or to augment the loads hauled by providing a more easy management of the boiler.

Upon this subject the annexed diagrams of the same trains, hauled by the same locomotive, and furnished with a

valved exhaust head and with the new exhaust, show clearly the progress realized. It constitutes an important advance in the power of this engine.

As practical result I confine myself to saying that we have increased by 35 tons (say a car, with trucks) the load originally fixed as a limit for our fast trains."

Conclusion.

26. The theoretical advantage and possible practical value of the variable exhaust have not been denied in the replies of motive power officers to the writer's inquiries, and the tenor of these replies is that its failure to be generally adopted in railroad service is largely, if not altogether, due to the fact that, under existing conditions, it does not seem possible to ensure it proper attention and protection from misuse on the part of engine crews. By reason of this, its advantages are not only thought by some to be negatived, but it is also believed by them that unless it can be so constructed and operated as to be effectually protected against the consequences of neglect and improper adjustment, positive disadvantage will result from its use. The following extracts from the replies referred to are here quoted as generally indicative of the views held in this matter by those having charge of motive power.

"1. In our opinion, a properly constructed variable exhaust nozzle could be used to decided advantage in locomotive operation, and I believe a satisfactory device of this kind can be produced.

2. I think that a properly designed variable exhaust would be very advantageous on any steam locomotive, and I do not see any reason why such application could not be made.

3. We are agreed that, if it is at all possible to get a perfect working variable exhaust, it is the one great want in locomotive performance.

4. I consider that a properly constructed variable exhaust would be of advantageous application on our locomotives, and, in my opinion, there is no reason why such application could not be made.

5. I see no reason why a properly constructed variable exhaust could not be installed to considerable advantage. Its success, of course, would depend upon the construction and application.

6. I am in favor of a properly constructed variable exhaust. . . . Should there be a successful variable exhaust developed, I would be glad to try a device of this kind out.

7. I do consider a varied exhaust, if properly constructed, would be advantageous to our locomotives, if same can be worked out so that they can be depended upon when wanted; but do not consider that any varied exhaust would be of advantage on our locomotives unless it could be controlled automatically and could be independent of operation by engine crews.

8. We realize there is an advantage in a device of this kind to further the efficient and economic operation of locomotives, provided it can be devised durable and fool-proof.

9. I consider a properly designed variable exhaust would be advantageous, especially where coal from different mines is being purchased, and I believe a properly designed variable exhaust could be applied. I also believe one properly handled by engine crew would be a money-maker in more ways than one.

10. I believe a properly constructed variable exhaust — one that would work when needed — would undoubtedly cause a saving in fuel consumption and reduce the back pressure in the cylinders.

11. Beg to advise that there have been no variable exhausts in use on this property. These would be a long step toward fuel economy.

12. Personally I have had no experience with variable exhausts, but think it might be a very desirable acquisition for locomotives, if it could be simply operated automatically.

13. A properly constructed variable exhaust would be of advantageous application to any locomotive.

14. We do not know of any reason why such an arrangement could not be used, and I am satisfied it would be of considerable advantage.

15. I have used variable exhausts on locomotives previous to coming to the ——— System, and believe they could be used to advantage, and see no reason why such application could not be made.

16. We are not using the variable exhausts on our engines. I have used them when running on the road, and believe that, when properly constructed, and properly handled, they are a source of economy in fuel.

17. There is no doubt, however, but what a properly constructed variable exhaust might be worth a thorough test; therefore, if it was practicable, would no doubt effect a considerable saving of fuel, and at the same time relieve the engine of back pressure.

18. I beg to state that our company have never used such an appliance, although I am of the opinion that a variable exhaust would prove a money-maker, if it were possible to arrange it to work automatically as the engine was working to full capacity or otherwise.

19. I would consider it a good thing providing the engineer in charge of the engine would pay strict attention to same and use it as it should be under the different conditions a locomotive is worked in handling a train over a division.

20. In my opinion, a properly constructed variable exhaust would be advantageous for locomotives in road service, but I do not feel that their application to switching locomotives would be productive of the best results.

21. I have always thought that the variable exhaust was a very good thing, but have never had any experience with them.

22. Unquestionably a variable exhaust will often be beneficial, and possibly prevent steam failures.

23. I would consider a properly constructed variable exhaust might be of considerable advantage if it worked automatically. I would not, however, favor any variable exhaust which was under the control of the engineer.

24. I have had no experience with variable exhausts, although I believe the variable exhaust tip is a good thing and that same could be successfully arranged.

25. I consider that such a device, properly designed and constructed, and connected to the reach rod or reverse lever in a way to make its operation automatic, placing it beyond the manipulation of the engineer, could be made productive of a great deal of good, particularly in the saving of fuel.

26. I believe that when a variable exhaust is properly constructed, so it could be handled, would be an advantage on a locomotive.

27. I am inclined to believe that a properly constructed variable exhaust would be an advantage on locomotives if properly maintained and handled by enginemen.

28. Some twelve or fifteen years ago I experimented quite extensively, and proved to my satisfaction the benefits of same, providing there was some way of controlling the human element that enters into their operation. The benefits of the variable exhaust under different conditions of the fire, and for various grades of coal, were very apparent; but it was my experience that what was necessary to handle the heavy, dirty, badly clinkered fire was the position that the nozzles were adjusted to, and, as a matter of precaution, the adjustment was usually made to such an extreme that it caused more severe action on the fire than was necessary or would have been permitted with a fixed nozzle. The result was that we were compelled to remove all variable exhausts and resort to the old method of fixed orifices.

Therefore, this is like many other good things that have had to be made fool-proof before they could be successfully operated, and must, in my opinion, be relegated to obscurity until some more successful method of controlling the human factor is devised.

29. If there was such a thing as an automatic variable exhaust, dependent upon the cut-off, I would then say that it was a good thing; but until that stage of perfection is reached I certainly would not advocate it.

30. There is no question but that a properly constructed variable exhaust would be an advantage to an engine, but it would necessarily involve some complication, both in construction and operation, which, to my mind, would more than offset its usefulness."

27. The view of the writer as to the variable exhaust is to the same general effect as those of members of the Association and others which are expressed in the above extracts from their letters, and he has brought this subject before the Association in the hope of sufficiently indicating its importance, to enlist the interest of the members and their considera-

tion of the advisability of its development in their service. If this interest and consideration be given, there is no room for doubt that a variable exhaust can be produced, in which the requirements called for in the replies of members would be fully complied with — that is to say, it would be "properly constructed," would be "automatically operable," and would be "fool-proof," because independent of the "human factor." Under the present conditions of railroad operation, the claims of this, as of every other appliance which is designed to operate in the direction of economy of fuel, merit a careful consideration on the part of motive power officers, and the standard of intelligence and ability of locomotive engineers at this time is so high that it would be unfair to them to believe that an appliance of such character, if approved by their superiors, would fail to receive fair and unprejudiced treatment in the operation of their locomotives.

28. This branch of the subject is clearly and comprehensively dealt with in a communication received by the writer from the General Superintendent of Motive Power of an important railroad system of the United States, which is here presented as being a better expression of the writer's position than could be formulated by himself, and is in the following terms:

> "I have always believed that the variable exhaust nozzle has decided merits, if freed from complications and made to a certain extent automatic. I am not at all satisfied that entire dependence upon the engineer for manipulation would be wise; it occurs to me that this might be controlled by the reverse lever.
>
> I would further suggest that it be so arranged as to provide against reducing the area of the nozzle below the standard or predetermined minimum area. This is in line with our standard practice in the case of fixed exhaust; we determine the minimum diameter for the various classes of locomotives operating under normal conditions. In other words, our practice is to fix upon a minimum diameter of exhaust nozzle for various classes of engines and runs, and do not permit, without special authority, a reduction of such minimum area. Unless this is provided for in the proposed variable exhaust nozzle, the advantages that could be derived from this device would be dissipated on the part of the engineer by an abuse of the opportunity to excessively restrict the area of the exhaust nozzle.
>
> The control of this device should provide for an increased area when starting, to avoid spark losses and blowing off of the pop valves, as well as a variation of the area to meet the requirements of the service; and this regulation should be, as far as practicable, automatic.
>
> I am of the opinion that if a satisfactory variable exhaust nozzle can be devised, there will result from its use not only great economy in the matter of fuel consumption and some in the matter of boiler maintenance, but also a saving in the matter of fires set out along the roadway and at cotton platforms.
>
> You, of course, are familiar with the types of variable exhaust nozzles which were brought out a number of years

ago, without general adoption. One is tempted to feel that a device which has been tried out and abandoned, as has been the case with the variable exhaust nozzle, is without merits. This is not always true, and may be an unwarranted assumption. It may simply be that the matter has not been carefully and fully developed. I am in hopes, therefore, that with the investigation you will give the subject, something may be developed that will assist in the economical and efficient operation of locomotives."

29. The thanks of the writer are returned to the members of the Association and others with whom he has been in correspondence for the expressions of their opinions, made in their replies to his letters of inquiry, and for the blue-prints and other data which they have kindly furnished relating to variable exhaust appliances with which they have had experience.

MR. J. SNOWDEN BELL: I have gone to some length in the paper into the origin of the variable exhaust, but have referred very briefly to it in the presentation, because they are illustrated fully in the paper.

With reference to the variable exhaust mentioned on page 16 and the latter part of page 15, our President informs me that he is using a number of devices of that kind to prevent fire to cotton and the like.

I wish to state that, subsequent to the preparation of this paper and after it was in print, I discovered by accident in a communication on an entirely different subject that Mr. Mertsheimer not only had developed a device of that kind, but had it in successful operation, and has had it in successful operation since last September on about twenty-six locomotives; and at the close of the discussion I will show photographs of it and a working model. Mr. Mertsheimer's name was in some way overlooked in sending out my circulars of inquiry, and therefore the incorrect statement appears in the paper.

Referring to the last paragraph on page 17, I want to say that I made inquiries as to that matter, as to the European practice, and it was developed that this Chemin du Nord appliance was the latest and, to use the expression of my informant, the "last word in variable exhausts in Europe to-day."

Referring to the statements on pages 18 to 22, those statements, as I say, are all of very recent date, November, 1914, of a very important railroad, which has been followed on other roads, and we all know the thoroughness and care with which

experiments are made in France and the nicety with which every detail of their locomotives is calculated and proven. I commend that statement, and I have read it in full for the attention, because I think it means a very important gain to be made by a proper variable exhaust.

What he says on page 25 about the fact that a non-successful trial had been made and therefore the subject had been abandoned, I think has a great deal of force. We all know that there may be some structural difficulty, there may be inattention on the part of those who are making the tests, or there may be prejudice against it, and therefore it seems to me that if a device is presented that appears to possess merit, the investigator should look at it himself, entirely regardless of how it impressed those who had previously made a trial of it, which trial, as I say, may have been made under unfavorable conditions, or made with prejudice on the part of those who were experimenting.

THE PRESIDENT: Gentlemen, you have heard this excellent paper. What is your pleasure? If there is no objection, it will be received and opened for discussion.

MR. C. A. SELEY: Mr. Chairman, in my younger days of youthful enthusiasm I became obsessed with the variable-nozzle idea. I had somewhat the idea as expressed in the first paragraph of this letter, which was quoted in paragraph 28, believing that a variable exhaust should be automatic, although I did not agree at that time with controlling it by the position of the reverse lever, for the reason that it seemed to me that the matter of draft should be connected with the matter of steam pressure, and not with reverse lever position. I got up quite a nice device, as I thought, and handed it over to a patent attorney to look into the state of the art, and he found a patented device identical in every particular with mine, and I naturally lost interest in the matter. That was a good many years ago, and there has been no practical development along that line since, and I think for the reason stated in the report several times that any device that is operated within the exhaust steam becomes inoperative on account of gumming up. While in the West recently, I saw the device which Mr. Bell mentioned as having been developed by Mr. Mertsheimer, and that gentleman is quite enthusiastic over

the device, believing, although not having made a scientific test of it, that he will save, not pounds, but tons, of coal. Briefly anticipating the pictures which Mr. Bell may show, I may say that the device is external to the exhaust stand, and consists of a bar above and across the top of the stand, which may be raised or lowered by external means without any chance of gumming up whatsoever. Any clogging tendency of the ways which carry that bar on the sides by cinder or dust is relieved by a special arrangement of the guides. Having personally seen the device, I speak of it as a development in the art, in addition to the information as given in Mr. Bell's paper.

Mr. MacBain: I think we ought to all feel thankful to Mr. Bell for his analysis of the progress of the variable exhaust, but for my part, in view of the attitude of the enginemen toward doing anything other than simply pushing and pulling, as you might say, I believe until we do get something that will work automatically, and almost humanly, that we had better stick to a sure thing and make the nozzle large enough to keep the engine steaming, and go along on that basis. I used this device fifteen years ago on the Michigan Central railroad, not in exactly the same form, but the principles were exactly the same in every way, and we found the conditions were just these: If the engineer or fireman thought about it, it was all right; they would open it sometimes, and sometimes they would not. At that time the engineers and firemen took greater interest in these things than they do now, I am sorry to say, but that is a fact, just the same. The practical way at the present time to insure good locomotive service is to make the locomotive, when it is turned out of the shop, as nearly foolproof as it can be made, because if you depend on any person, other than your mechanical arrangement and the men who make these arrangements for you, you are going to lose on the proposition.

We have developed a great many things in the last fifteen or eighteen years, and there are many divergent opinions as to what is necessary in the front end of locomotives to create a proper draft, and my own personal experience has been that the thing to do is to make the nozzle as large as consistent and at the same time design your nozzle so that the steam column from the

cylinders will pass it without raking the sides of the stack in any direction. When you do that you allow space around the circumference of the steam column for the gases to be entrained and carried out.

It might be of interest to note that a few years ago we took means to find out what the pressure of the exhaust steam was at the various points from the side of the nozzle up to the top of the stack of a freight locomotive. We found that it left the top of the stack at a pressure of about five pounds. When you come to consider that you have five pounds pressure in a solid column of steam, it is rather inconsistent to believe that any quantity of the front-end gases are going to crowd themselves into that column of steam and be carried out, so what you have to figure on is a column of steam of great enough circumference to entrain a sufficient amount of gases per minute in order to create the desired draft.

I happened to make a note here a little while ago from a personal record that we have kept in our office of the engine failures on the line of the New York Central road, and out of a large number of locomotives operated I find that our steam failures for the year 1914 were 46; and 146 failures due to leaking. I will not say anything about the service of the railroad. I will leave that to everybody else to judge for themselves. We have a pretty good old railroad now, right from New York to Chicago, but when you can operate a thousand locomotives satistorily as we have operated them in the year 1914, and have as few failures — boiler and steam failures — as we have had, I believe you are pretty near hitting the ball. [Applause.]

Mr. Pratt: That is west of Buffalo, isn't it?

Mr. MacBain: Yes, sir; west of Buffalo.

The President: Are there any others who would like to talk on this subject?

Mr. G. W. Wildin (N. Y. N. H. & H. R. R.): I want to congratulate Mr. MacBain on the record he has made. I would be very much more enlightened if he would simply define what a failure was on his railroad. It was my pleasure to take a trip last January to the West over several railroads, and one of the

principal things that I was investigating was: What was called an engine failure. We always hear about the miles we make per engine failure. Unless you have got a standard basis for an engine failure, your comparison does not amount to much. I would just like to know.

MR. MACBAIN: I was not talking about engine failures. I was talking about steam and boiler failures only, which comprise, I am very sorry to say, a small number of the whole. A steam failure is a failure where your engine fails to steam to the point where you lose five minutes or more on the schedule, and a boiler failure is the same thing. Any failure that we have is classified in the same way. This is not taken from the official engine-failure record; it is taken from a record kept in our office, as we keep the boiler records and everything else, for the purpose of knowing ourselves and not for fooling anybody, but we want to know how we are getting along.

MR. WILDIN: Mr. President, that is all right. We are all trying to do that. But suppose you make up the time after you have lost it, do you count it failure?

MR. MACBAIN: Oh, absolutely not. If we go in on time, we do not count it.

MR. WILDIN: That is exactly it. So that he does not keep his engine failures. [Laughter.] Now, I find that existing all over the country, and we are only fooling ourselves. If you have five minutes' detention for steam, I do not care whether you make up the time or not, you have it.

MR. W. E. SYMONS: Mr. President, I also want to congratulate Mr. MacBain on his splendid engine-perforance records, particularly the absence of engine failures. Mr. Wildin's suggestion as to the lack of uniformity or a definite manner of measuring an engine failure is important; otherwise the term "engine failure" does not mean anything. I may be pardoned if I suggest this as a slight digression from the subject which is now before this body. The variable exhaust nozzle and the field which it properly occupies in locomotive design and operation is one that should receive, I think, considerable attention.

I myself am very proud of the fact that the motive power

officers of American railways have developed a machine that will deliver a horse-power at the draw bar with less than two pounds of coal. That is a record of which any man should be proud, and I myself would not say a word that would detract from the proper credit due to those who have developed the engine up to that point. But in our work of developing the American locomotive we have in a measure worked in cycles, or I might say that we have at times almost imitated the fair sex when they rush for a bargain counter on Monday morning, in that we too often direct our energies to one particular part of the locomotive, neglecting other essential parts that sometimes offer a more inviting field for development.

Some years ago we became enthused over the compound engine, which principle is a good one; no engineer can say that it is not without doing violence to his reputation as such. We found great economies from its use, or it was thought so. In fact, on the convention floor of this body it was stated by able men that compound locomotives could be operated, lubricated and repaired for less than simple engines, while at the time the statement was made some compound engines were costing as much as 20 cents per mile for repairs alone, which shows the matter had not been carefully analyzed.

We then took up the question of superheating locomotives, which principle is an excellent one, and gives good returns on the investment, but superheating was old when compounding was first thought of; but we looked way beyond it, as it were, actually ignoring this principle in our development work of the locomotive, although our efforts were to produce a more effective and economical unit of transportation.

The superheater, however, although a decided improvement, is rather an expensive device when compared to some of the minor details of the locomotive, such as the exhaust nozzle, and as the exhaust nozzle on all kinds of engines, regardless of whether they are saturated steam, compound, superheated, or not, is the medium through which the back pressure on the pistons is largely effected, and therefore controls, in a measure, the economical operation of the machine. It is a feature that should have had our attention in the past, and should now be included in

the field of investigation or research work in connection with developing a more economical machine for transportation.

I have known of an instance of an engine with less than twenty-five thousand pounds tractive power, equipped with a variable exhaust nozzle, when running at high speed, the engineer could, by a slight movement of a handle in the cab, increase its horse-power from 900 to 1000, thus increasing its efficiency in a remarkable degree. I have seen some statements from one of the leading railroads of this country where the back pressure on pistons of certain engines was as much as 800 to 1000 horse-power. Whether any successful effort was made looking toward a reduction of the back pressure mentioned, I do not know, but it does seem to me that in our efforts to reach economical results in locomotive operation, we sometimes strain our eyes for nickels and pennies, and at the same time some of us have stumbled over $5 bills. If a locomotive can be relieved of back pressure by the application of a device costing possibly $50 or less, and in some instances $20 or less, that will increase its efficiency as much as 10 or 15 per cent, then it is a reflection on the intelligence of this body of men, and on the motive power officers of America, to assume that we can not devise a method to relieve that situation and effectually control it.

I know that Mr. Wildin, who just spoke on the subject, did work out a device that materially increases the effectiveness of the locomotive, possibly 10 or 15 per cent, although he is too modest to say anything about it.

Again referring to Mr. MacBain's engines, I can say they are in good condition, as I travel considerably over the line with which he is connected, and can testify to what he has said in reference to engine failures. I hope he will pardon me if I suggest that the degree of efficiency in some cases might be slightly increased if he had his engines equipped with a device for controlling the exhaust nozzle, and thus relieve the pistons of back pressure, which in a certain sense compares to the adverse effects of brakes sticking, and reduces in a very considerable degree the efficiency of the locomotive.

I think this subject opens a productive field of investigation and one that should be followed up.

The President: Any further discussion?

Mr. Elmer: Mr. President, I rather gather from the conclusions of the paper that Mr. Seley's device was, à priori, doomed to failure. In other words, while it might be desirable from some points of view to have a variable exhaust nozzle dependent upon the steam pressure, it would seem to be very important to have a nozzle which could be large when the engine is working in full gear and reduced when the engine is hooked up.

There is also one comment which I think should be made. On page 21 the statement is given that in superheater engines it is necessary to choke the exhaust as much as 15 per cent.

On the floor of the convention the other day it was stated that the superheated steam released at the instant of exhaust was of greater volume than the saturated steam, and it would therefore appear that a conflict existed between these two statements. One or the other should be modified to such an extent as is necessary to make the facts agree.

If the device shown on page 20, worked by the French railroad, is satisfactory, why could not the two functions of that shown on page 20 and that shown on page 15 in the upper cut, No. 15, be combined, so that the perfect device mechanically which has been produced on the French railroads may be joined to the operative features by control of the reverse lever and a satisfactory device for American railroads developed?

The President: Mr. Bell, would you like to make some closing remarks?

Mr. Bell: Just a word, Mr. President. This variable exhaust of Mr. Mertsheimer's, as explained by Mr. Seley and shown on the photograph — there is a model of it here which I will leave on the table; if any member is curious to look into it further, he can do so. While I am not at all a representative of Mr. Mertsheimer, I think it is only fair to state a few words of what he said to me in sending me this material. He says:

"It has been in operation since last September, and we have it now on twenty-five or twenty-six engines, and it never has given us any trouble in regard to sticking, or otherwise. There has not been one penny spent on it for repairs. It is simple, and

there is nothing complicated about it to give out. In fact, it is always ready for service.

"We are getting excellent results from this, so much so that it has warranted us in putting it on all the engines we have, and we are applying it as fast as we can. We have shown a saving on many of our engines from one to one and one-half tons, and in some cases two tons, per trip of 125 miles, and have never had a steam failure on any of the engines we have used it on, although we have gotten some bad coal at times. The fireman is enabled to keep the engine right up to full pressure at all times. We have cut out fire-cleaning on the line, when previously we invariably cleaned fires each and every trip. Our engines arrive at terminals with a very light fire on the grates, and the fire is invariably cleaned in a very short time, and in many cases we have been able to run engines through terminals without cleaning fire, where heretofore it has been with loss of time, using clinker bars, etc., and detriment to the flues on account of having the fire door open and the blower on. We are applying the nozzle to our locomotives at a cost of $12.85 each."

I quite agree with what Mr. MacBain said with regard to making the locomotive foolproof and doing everything we can toward simplification. The best theory in the world fails in the face of a defect in practice, and a device which in theory is perfect may in practice be worse than useless; but at the same time, as suggested by Mr. Symons, I do not see that there has been any objection made by any one to the theory of the variable exhaust, and I see no reason why some one can not devise a variable exhaust which will be satisfactory and practicable, and exempt from these conditions. In formulating a design it is just as important to know what to avoid as to know what to do, and many of the old examples given in the paper were for that purpose. Some of them were obviously undesirable, and are the things to keep away from.

At the same time it seems to me that we have enough mechanical ability among our members to devise something which will be practically workable. I think that any motive power officer who fails to give investigation to something which promises fuel economy, and which is not obviously undesirable and imprac-

ticable, is not doing his full duty to his company. I think he should investigate any device which offers any reasonable claim for recognition. If the device fails after that investigation, his duty is performed.

With regard to the gentleman who spoke of the reduction of the exhaust to the extent of 15 per cent more on superheater locomotives, I want to say that is not my statement, but the statement in Mr. Asselin's report. He says that is their practice. I am informed by Mr. Ennis, of the American Locomotive Company, that their practice is the same. He did not say 15 per cent, but he said that the nozzles are contracted on superheater locomotives. So, whatever variation there is in the statement, I am not passing on the correctness of it, but am simply setting forth the statement which has been made to me.

Mr. Pratt: I perhaps should have said what I am about to say before Mr. Bell finished. I want to connect Mr. MacBain's statement with the old practice. Mr. MacBain says the men do not take as much interest in these matters as formerly. That is undoubtedly true. Maybe it is our fault that they do not, but the Patent Office does not contain a record of the first nozzle-reducing device which came to my notice. Perhaps others have seen a clinker bar stuck down the stack into the exhaust nozzle, and many engines going over roads and getting into the terminals on time as a result of it. We have taken the clinker bars off, so that we can not now blame our engineers for not using that variable exhaust.

The President: If there is no further discussion, we will consider the matter closed.

We will now take up the report of the Committee on Joint Meetings of the American Railway Master Mechanics' Association and the Master Car Builders' Association. Mr. C. F. Giles, S. M., L. & N. R. R., will present the report.

Mr. Giles presented the report, as follows:

REPORT OF COMMITTEE ON JOINT MEETINGS.

To the Members:

Your Committee on Joint Meetings of the two Associations submits herewith a tentative program based on the work to be done at the 1915 Convention, to indicate how the two conventions could be held in one week.

It will be noted that at the joint session held on Wednesday, June 9, several reports which are common to both Associations are scheduled for discussion. It is possible that other reports might also be added.

The committee itself believes some such a plan is feasible, but would not recommend that it be done, believing that much better results are obtained from these conventions by following the present plan of holding each convention separately.

Respectfully submitted,

J. F. De Voy,	R. W. Burnett,
C. E. Chambers,	J. S. Lentz,
C. F. Giles,	T. H. Goodnow,
Committee A. R. M. M. Assn.	*Committee M. C. B. Assn.*

JOINT PROGRAM

OF THE

Forty-eighth Annual Convention

OF THE

American Railway Master Mechanics' Association

AND THE

Forty-ninth Annual Convention

OF THE

Master Car Builders' Association

ATLANTIC CITY, N. J.,

June 7, 8, 9, 10 and 11, 1915.

FIRST DAY.

AMERICAN RY. M. M. ASSOCIATION

Monday, June 7, 1915

9.30 A. M. to 1.30 P. M.

Prayer	9:30 A.M. to 9:35 A.M.
Address of President	9:35 A.M. to 9:50 A.M.
Intermission (To allow those who wish to retire to do so, although all are requested to remain.)	9:50 A.M. to 9:55 A.M.
Action on Minutes of Convention of 1914	9:55 A.M. to 10:00 A.M.
Reports of Secretary and Treasurer	10:00 A.M. to 10:15 A.M.
Assessment and announcement of dues; appointment of Committees on Correspondence, Resolutions, Nominations, Obituaries, etc	10:15 A.M. to 10:25 A.M.
Election of Auditing Committee	10:25 A.M. to 10:30 A.M.
Unfinished Business	10:30 A.M. to 10:35 A.M.
New Business	10:35 A.M. to 10:45 A.M.
Discussion of Reports on:	
Mechanical Stokers	10:45 A.M. to 11:00 A.M.
Smoke Prevention	11:00 A.M. to 11:30 A.M.
Fuel Economy	11:30 A.M. to 12:00 M.
Design, Construction and Inspection of Locomotive Boilers	12:00 M. to 12:30 P.M.
Locomotive Headlights	12:30 P.M. to 1:00 P.M.
Individual Paper on Variable Exhausts by J. Snowden Bell	1:00 P.M. to 1:30 P.M.

Adjournment.

SECOND DAY.

Tuesday, June 8, 1915

9.30 A. M. to 1.30 P. M.

Discussion of Reports on:

Superheater Locomotives	9:30 A.M. to 10:00 A.M.
Standardization of Tinware	10:00 A.M. to 10:15 A.M.
Locomotive Counterbalancing	10:15 A.M. to 10:45 A.M.
Electrical Equipment	10:45 A.M. to 11:00 A.M.
Forging Specifications	11:00 A.M. to 11:30 A.M.
Train Resistance and Tonnage Rating	11:30 A.M. to 12:00 M.
Boiler Washing	12:00 M. to 12:15 P.M.
Dimensions of Flange and Screw Couplings for Injectors	12:15 P.M. to 12:45 P.M.
Subjects	12:45 P.M. to 12:50 P.M.
Unfinished Business	12:50 P.M. to 1:00 P.M.
Election of Officers, Closing Exercises	1:00 P.M. to 1:30 P.M.

Adjournment.

JOINT SESSION

AMERICAN RY. M. M. ASSOCIATION

AND

MASTER CAR BUILDERS' ASSOCIATION

Wednesday, June 9, 1915

9.30 A. M. to 1.30 P. M.

Discussion of Reports on:

Safety Appliances	9:30 A.M. to 9:45 A.M.
Revision of Standards and Recommended Practice	9:45 A.M. to 10:15 A.M.
Revision of Air Brake and Train Air Signal Equipment	10:15 A.M. to 10:30 A.M.
Car Wheels	10:30 A.M. to 10:45 A.M.
Revision of Rules of Interchange, including Arbitration Committee Report. Revision of Prices for Labor and Material	10:45 A.M. to 1:30 P.M.

Adjournment.

FIRST DAY.

MASTER CAR BUILDERS' ASSOCIATION

Thursday, June 10, 1915

9.30 A. M. to 1.30 P. M.

Address by the President	9:30 A.M. to 10:30 A.M.
Reading of the Minutes of the last Meeting	10:30 A.M. to 10:35 A.M.
Report of Secretary and Treasurer	10:35 A.M. to 10:50 A.M.
Assessment and announcement of annual dues; Election and Appointment of Committees, Unfinished and New Business	10:50 A.M. to 11:00 A.M.
Discussion of Reports on:	
Nominations	11:00 A.M. to 11:05 A.M.
Brake Shoe and Brake Beam Equipment	11:05 A.M. to 11:20 A.M.
Couplers	11:20 A.M. to 11:45 A.M.
Draft Gear	11:45 A.M. to 12:15 P.M.
Car Trucks	12:15 P.M. to 12:30 P.M.
Car Construction	12:30 P.M. to 1:00 P.M.
Loading Rules, including Overhead Inspection	1:00 P.M. to 1:30 P.M.

Adjournment.

SECOND DAY.

Friday, June 11, 1915

9.30 A. M. to 1.30 P. M.

Discussion of Reports on:

Specifications and Tests for Materials...	9:30 A.M. to 10:30 A.M.
Train Lighting and Equipment.......	10:30 A.M. to 10:45 A.M.
Tank Cars..........................	10:45 A.M. to 11:00 A.M.
Settlement Prices for Wooden Cars....	11:00 A.M. to 11:30 A.M.
Compensation for Car Repairs........	11:30 A.M. to 12:00 M.

Unfinished Business:

Reports of Committee on Resolutions, and such other Committees as may be named during the Convention....	12:00 M. to 12:30 P.M.
Election of Officers. Closing Exercises...	12:30 P.M. to 1:30 P.M.

Adjournment.

THE PRESIDENT: What action will you take on this report of the committee?

MR. DUNHAM: I move that this report be referred to the Executive Committee for further consideration.

Motion seconded and carried.

THE PRESIDENT: The next business is the report of the Committee on Revision of Air Brake and Train Air Signal Instructions, Mr. R. B. Kendig, Chairman.

THE SECRETARY: This committee is a joint committee of the Master Car Builders' Association and the American Railway Master Mechanics' Association. There will be no report presented by this committee at this convention, as there have been no developments in the work of the committee affecting locomotives.

THE PRESIDENT: Unless there is objection, the statement by the Secretary will be accepted in lieu of the report of the committee.

We will now have the report of the Committee on Train Resistance and Tonnage Rating, Mr. P. F. Smith, Jr., S. M. P., Penna. Lines, Chairman.

Mr. Smith presented the report, as follows:

REPORT OF COMMITTEE ON TRAIN RESISTANCE AND TONNAGE RATING.

To the Members:

Your committee has, in accordance with instructions, endeavored to get additional information to enable it to submit a final report at this Convention.

While some information has been available, yet we desire additional data as to the comparison of the drawbar pull curve of superheater locomotives, as compared with that of saturated locomotives. Also, we desire data as to the resistance of the ninety-ton cars now coming into use.

We will be able to obtain the information desired and submit a final report to the Association in 1916, and would ask your permission to carry over the final report to that time.

P. F. SMITH, JR., Chairman,
W. E. DUNHAM,
J. S. SHEAFE,
H. C. MANCHESTER,
C. E. CHAMBERS,
J. H. MANNING,
FRANK ZELENY,
Committee.

THE PRESIDENT: What action will you take on this report?

MR. MACBAIN: I move that the report be accepted as read and the subject left in the hands of the committee for another year, as recommended by the committee.

Motion seconded and carried.

THE PRESIDENT: The next business will be the report of the Committee on Counterbalancing. Mr. S. G. Thomson, S. M. P. & R. E., Phila. & Reading R. R., is Chairman.

Mr. Thomson presented the report, as follows:

REPORT OF COMMITTEE ON COUNTERBALANCING.

To the Members:

Your committee has been appointed to supplement the work done on this subject by a similar committee during 1896–97, and to summarize the practice to date.

The following report will consider only the counterbalancing of two-cylinder locomotives, the three and four cylinder locomotives being less of a problem on account of the reciprocating parts more or less balancing each other. Locomotive having separate pairs of engines, such as the Mallet and other types, will of course have each pair of engines subject to the same counterbalancing laws as the two-cylinder locomotive.

Methods of testing for correcting counterbalance, weighing wheels and rods, etc., and forms used in shops for recording and checking, will not be included in this report, since in these methods each railroad has conditions and designs peculiar to itself to which it must fit its shop practice. A uniform method of weighing and balancing wheels, together with the equipment used for this purpose, is given in the 1896 Counterbalancing Report.

In order that the subject may be readily comprehended, the entire report will deal only in simple terms and will present the subject matter without introducing the use of elaborate formulae and other technicalities.

MAIN PRINCIPLES INVOLVED IN LOCOMOTIVE COUNTERBALANCING

These principles may be illustrated diagrammatically by Figs. 1 to 4. The radius of the circle, in each case, represents the centrifugal force of the overbalance or, in other words, the centrifugal force of the weight added to partly counterbalance the reciprocating parts. The revolving parts may be assumed to be perfectly balanced, so that the weight added for that purpose need not be considered and is not represented in these diagrams. The weight added for partly balancing the reciprocating parts is the overbalance which

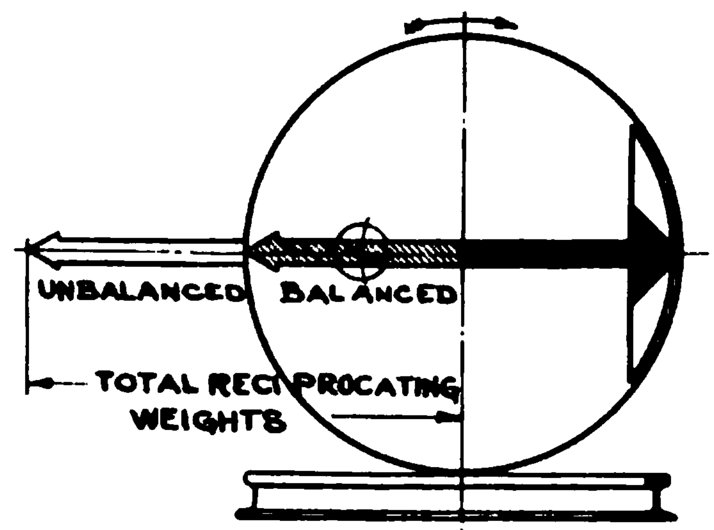


Fig. 1

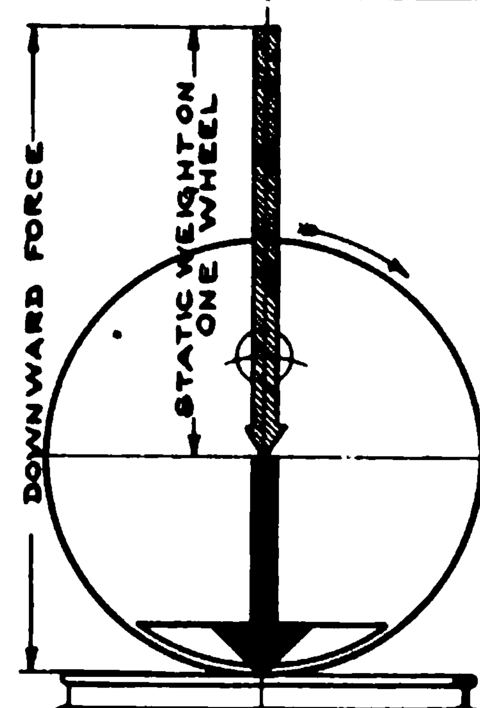


Fig. 2

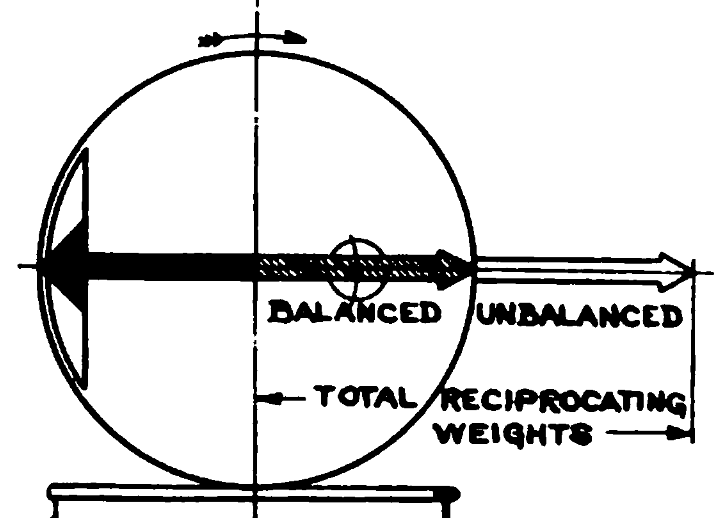


Fig. 3

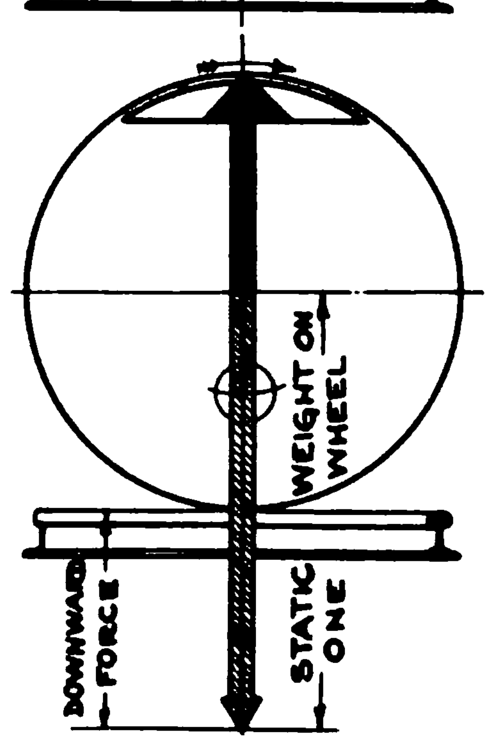


Fig. 4

distorts the otherwise perfectly balanced revolving parts. This overbalance is represented in all four diagrams by parts shown black.

Fig. 1. Represents, by shaded and unshaded portions, the total weight of reciprocating parts, the shaded portion within the circle being balanced by the overbalance when the wheel is in the position shown. The portion without the circle is the unbalanced weight of reciprocating parts, which tends to cause a nosing or fore and aft irregular movement of the locomotive.

Fig. 2. Shows the position of the wheel after a quarter-turn, in which the effect of the unbalanced reciprocating parts is eliminated, and the distorting forces are caused by the centrifugal force of the overbalance acting in a downward direction, the resultant effect on the track being the static weight on the driving wheel plus the centrifugal force of the overbalance. This position gives the greatest pressure on the rail.

Fig. 3. Is similar to Fig. 1, and shows the effect of unbalanced reciprocating parts in the opposite direction, after another quarter-turn. There are, however, slight differences in the effect shown in Figs. 1 and 3, due to angularity of connecting rods, etc., but this need not be considered.

Fig. 4. Shows the downward force on the track when crank pin is down and overbalance is up, this force being the difference between the static weight on driver and centrifugal force of the overbalance. This position gives the least pressure on the rail. The proportions in this figure show the overbalance to neutralize about one-half the static weight on the wheel, leaving half the static weight as the downward force on the track for this position of the crank.

These diagrams represent conditions at high speed.

GENERALLY ACCEPTED RULES AND PRINCIPLES.

The reciprocating parts to be considered in counterbalancing are: The piston head, rod and nut; the cross-head, cross-head key, pin and nuts; approximately one-half the total weight of the main rod; arm and link fastened to cross-head for outside valve gear.

Each driving wheel should have sufficient weight added to counterbalance exactly the weight of its revolving parts, which are: Crank pin, crank-pin hub, and the proportion of the weight of the side rods attached to the pin. The main driving wheel should have added approximately one-half the total weight of the main rod, plus two-thirds the weight of the eccentric arm, considered acting at crank pin distance, for outside valve gear.

Cross-counterbalancing, to correct the disturbances caused by the parts revolving in different planes, is thought to be unnecessary with outside cylinders, on account of the disturbing forces being slight when compared to the principal reciprocating and centrifugal forces.

The overbalance which is used to counteract the desired portion of the weight of the reciprocating parts should be distributed as nearly equally as possible among all driving wheels, adding to it the weight of the revolving parts for each wheel. This sum for each wheel, if placed at a distance from

the driving wheel center equal to the length of the crank, or a proportionally less weight if at a greater distance, will be the counterbalance required.

Centrifugal and reciprocating forces are usually figured at a speed in miles per hour equal to the diameter of the driving wheel in inches, which may be considered as a maximum for good practice. This is ordinarily referred to as "diameter-speed." At this speed the reciprocating parts, due to the laws of inertia, tend to continue their motion at the end of each stroke with a force about equal to 40 times their weight. (#) The overbalance exerts a centrifugal force equal to about 40 times its weight, and is at a maximum at the top and bottom position of the crank. This force is added to the static weight, in the lower position of the overbalance, and is opposed to this weight, in the upper position, as shown in Fig. 2 and Fig. 4. Approximately one-fortieth of the static weight on a wheel will therefore give the weight of the reciprocating parts which could be balanced without causing the wheel to rise from the track at diameter-speed. This amount of balance would also double the load on the rail when the balance is down.

(#) The dynamic augment varies with the stroke.

If W = overbalance or excess weight at one-half stroke distance,
then with 18-in. stroke, dynamic augment $= 29.1 \times W$ at diameter-speed.
then with 20-in. stroke, dynamic augment $= 32.3 \times W$ at diameter-speed.
then with 22-in. stroke, dynamic augment $= 35.5 \times W$ at diameter-speed.
then with 24-in. stroke, dynamic augment $= 38.5 \times W$ at diameter-speed.
then with 26-in. stroke, dynamic augment $= 41.7 \times W$ at diameter-speed.
then with 28-in. stroke, dynamic augment $= 44.9 \times W$ at diameter-speed.
then with 30-in. stroke, dynamic augment $= 48.4 \times W$ at diameter-speed.
then with 32-in. stroke, dynamic augment $= 51.7 \times W$ at diameter-speed.
then with 34-in. stroke, dynamic augment $= 54.9 \times W$ at diameter-speed.

METHODS FOR DETERMINING THE AMOUNT OF OVERBALANCE.

The method most generally used for many years in counterbalancing locomotives has been to balance a portion of the total weight of the reciprocating parts, usually about two-thirds.

A second method, and the one recommended in the 1896-97 reports to the Master Mechanics' Association, is to leave unbalanced, on each side of the locomotive, a portion of the reciprocating parts equal to 1-400 of the weight of the locomotive.

Neither of the above methods seems to give good results in all cases, and your committee would therefore like to present another relationship which seems paramount to proper counterbalancing: The ratio of the total weight of the reciprocating parts on each side of the locomotive to the total weight of the locomotive in working order.

To show the necessity for this ratio, and to demonstrate the failure of the former rules when applied to locomotives with heavy reciprocating parts running at high speed, your committee has made some tests on the Philadelphia & Reading Railway, as shown on Plate I. These tests included a

NUMBER	TYPE	WHEEL	WEIGHT OF ENGINE	WEIGHT OF RECIP. PARTS	RECIP. / ENGINE	RECIPROCATING PARTS BALANCED WEIGHT	RECIPROCATING PARTS BALANCED %.	RECIPROCATING PARTS UNBALANCED WEIGHT	RECIPROCATING PARTS UNBALANCED %.	UNB. WT. / ENGINE	STATIC WEIGHT PER WHEEL	DYNAMIC AUGMENT PER WHEEL	%. INC. WEIGHT 60 MILES PER. HR.	REMARKS
345	4-4-2	80"	224000	1616	$\frac{1}{139}$	1115	69	501	31	$\frac{1}{447}$	32250	23500	72	VERY ROUGH AT HIGH SPEED
345	4-4-2	80"	224000	1616	$\frac{1}{139}$	485	30	1131	70	$\frac{1}{198}$	32250	10220	32	EXCESSIVE FORE AND AFT.
345	4-4-2	80"	224000	1521	$\frac{1}{147}$	760	50	761	50	$\frac{1}{294}$	32250	16027	49.7	FORE AND AFT. FAIRLY ROUGH AT HIGH SPEED
346	4-4-2	80"	224000	1616	$\frac{1}{139}$	1034	64	582	36	$\frac{1}{385}$	32250	21800	67	ROUGH AT HIGH SPEED
341	4-4-2	80"	224000	1616	$\frac{1}{139}$	888	55	728	45	$\frac{1}{308}$	32250	18750	58	GOOD AVERAGE ROUGH AT HIGH SPEED
347	4-4-2	80"	224000	1616	$\frac{1}{139}$	773	48	843	52	$\frac{1}{266}$	32250	16350	50	FORE AND AFT. FAIR AT HIGH SPEED
342	4-4-2	86"	222500	1370	$\frac{1}{164}$	985	72	385	28	$\frac{1}{578}$	31750	18425	58	GOOD AVERAGE SLIGHTLY ROUGH AT HIGH SPEED
301	4-4-2	80"	217000	1273	$\frac{1}{170}$	916	72	357	28	$\frac{1}{608}$	30500	19300	63	GOOD AT LOW SLIGHTLY ROUGH AT HIGH SPEED
301	4-4-2	80"	217000	1273	$\frac{1}{170}$	636	50	637	50	$\frac{1}{341}$	30500	13426	44	GOOD AVERAGE GOOD AT HIGH SPEED

PLATE 1

series of high-speed locomotives having very heavy reciprocating par equal to 1-139 of the total weight of the locomotive.

One of this series of locomotives, No. 345, had 69 per cent of the rec rocating parts balanced, and was so rough at high speed that many pa of the locomotive were being continually shaken loose, thus disproving rule requiring about two-thirds of the weight of the reciprocating parts to balanced. This locomotive also had 1-447 of its total weight unbalanc which also disproves the second method of calculation.

Three more of these locomotives, Nos. 346, 341 and 347, were count balanced with 64 per cent, 55 per cent and 48 per cent, respectively, of weight of their reciprocating parts balanced, which was 1-385, 1-308 1-266 part, respectively, of their total weight unbalanced. The best rid of these locomotives was No. 341, with 55 per cent or a little more than h of the weight of its reciprocating parts balanced. But this locomotive h too much fore and aft motion at moderate speed, due to the very heavy rec rocating parts. This fore and aft motion, however, was largely absorb at the higher speeds, and a considerable vibration, due to the vertical for of the overbalance, took its place; showing that, with such heavy recip cating parts, even as low a portion as 55 per cent was too much overbala for high speed. No. 347, with 48 per cent balanced, was not so bad in vibrations at high speed, but had an excessive fore and aft motion at moderate speeds.

The test of No. 345, therefore, with 69 per cent of its heavy reciprocat parts balanced as mentioned above, shows that it is the overbalance wh makes a locomotive rough at high speeds, rather than too great an amo of the weight of the reciprocating parts left unbalanced. In other wor the fore and aft or nosing effect of unbalanced reciprocating parts seems become absorbed, in passing through the moderate speeds, and the ov balance then becomes the disturbing factor at the higher speeds in sett up excessive vibration.

Locomotives 342 and 301, having lighter reciprocating parts and w 72 per cent balanced, seem to be well proportioned to prevent fore and movement, but the large percentage of overbalance necessary to accompl this makes them rough at very high speed.

It will be noted that locomotives 341 and 301, which ride very mu the same at high speed, have 1-308 and 1-608 part, respectively, of their to weight unbalanced; showing that this method of calculation is not relia for the higher speeds. It will be noted, also, that the dynamic augment these two locomotives is about the same.

It would therefore seem, from the above results, that the riding of locomotive at high speed can be greatly improved by reducing the weig of the overbalance. This can be done either by increasing the amou left unbalanced, or by reducing the total weight of the reciprocating parts.

With a view of determining what proportion of the reciprocating pa can be left unbalanced, the counterbalancing of 345 was changed to 30 p cent balanced and 70 per cent unbalanced, which, for these very heavy rec

rocating parts, represented excessive conditions, shown by the fact that as much as 1-198 of the total weight of the locomotive was unbalanced, instead of 1-400 as per the former rule. This locomotive had excessive fore and aft movement, too great for service even at low speed, but had no perceptible vibration due to vertical forces at high speed.

A second test was made with the 301, with 50 per cent of the weight of the reciprocating parts balanced, which was equal to 1-341 part of the weight of the locomotive. This gave better results than any of the tests with locomotive having the heavier reciprocating parts.

We can conclude from the above tests that the lighter the reciprocating parts can be made, the better results will be obtained. We can also conclude, when counterbalancing for very high speed, that a larger portion of reciprocating weights can be left unbalanced than has been the practice.

In order to more closely study the relation between the total weight of reciprocating parts and the total weight of locomotive, and in order to show the tendency in recent years toward heavy reciprocating parts, your committee has collected some data, shown on Plate II. This table classifies the locomotives into freight and passenger built before and since 1904. It also shows, separately, several locomotives built during 1914, with very light reciprocating parts. It will be noted, from this table, that this average relative weight of reciprocating parts, both freight and passenger, is greater for locomotives built since 1904 than prior to that date. The group of locomotives built during 1914 shows what can be accomplished in making light reciprocating parts, when a special effort is exerted along these lines. By a careful analysis of this table one can readily see just what the weights and ratios of the various parts have been, as well as what can be used for the various classes, kinds and weights of locomotives. It may be seen, in the thirteenth column, just how many pounds force is exerted against the piston per pound of reciprocating parts. These figures are a good measure of the efficiency of reciprocating parts, and show some very interesting results.

CONCLUSIONS.

A simple counterbalancing rule expressed in general terms, which should give good average results when applied to any class of locomotives in any service, might be stated as follows:

Keep the total weight of the reciprocating parts on each side of the locomotive below 1-160 part of the total weight of the locomotive in working order, and then balance one-half the weight of the reciprocating parts.

The above general rule is based upon diameter-speed, and should keep the dynamic augment well within the limits of good practice. Where the normal speed is regularly considerably below the diameter-speed, it may be desirable to increase the proportion of the reciprocating weights to be balanced, to as much as 60 per cent or 65 per cent.

Another counterbalancing rule is, to set an arbitrary percentage which

the dynamic force of the overbalance will be allowed to increase the static weight; for example:

If it is desired that the dynamic force of the overbalance at a speed in miles per hour equal to the diameter of the driving wheel in inches, should not increase the static weight on a wheel more than 50 per cent, calculation could be made as follows:

4-4-2 type locomotive with 26-in. stroke.

Given: Static weight on one wheel = 30,000 lb.

To find: Maximum permissible weight of reciprocating parts to be balanced in one wheel = W.

$$W = \frac{\text{50 per cent static weight on one wheel} \times .312}{\text{Crank radius in inches.}}$$

$$W = \frac{15\,000 \times .312}{13} = 360 \text{ lb.}$$

Therefore: The total reciprocating weight to be balanced on one side of this locomotive would be 720 lb. And with 50 per cent of the total reciprocating parts balanced on one side, the total weight of these parts must be designed to weigh 1440 lb.

The converse of this is:

Given: Weight of reciprocating parts balanced in one wheel, W = 360 lb.

To find: Dynamic augment = A.

$A = W \times 3.2 \times$ crank radius in inches.

$= 360 \times 3.2 \times 13 = 15{,}000$ lb.

Therefore: 15,000 lb. dynamic weight is added to the 30,000 lb. static weight, giving a total of 45,000 lb. on the rail.

The dynamic augment may be expressed in percentage of the static weight on one driving wheel. These static weights, dynamic augments and percentage increases in weights are given as illustrations in connection with tests shown on Plate I, where it will be seen that the percentage increase varies from 32 per cent to 72 per cent. Your committee, however, believes that 50 per cent increase in the static weight on the driver at diameter-speed would represent good average practice, while much less than this percentage is greatly to be desired.

Your committee concludes, therefore, that the secret of proper counterbalancing for any class of locomotive in any service is to reduce the weight of the reciprocating parts as far as possible. They should be made lighter than the average practice as shown on Plate II; and in the construction of new locomotives, they should be more in line with those built in 1914, with specially light reciprocating parts.

Great benefit will be obtained if the railroads will determine the maximum load that they can carry on the rails, bridges, etc., and then reduce the weight of the reciprocating parts to a point where the dynamic augment of the parts balanced will be only a small proportion of this maximum allowed load.

Special designs of piston heads, cross-heads, hollow piston rods, and the use of high-grade materials, including heat-treated carbon and alloy steel, aluminum, etc., make it possible to construct very light parts, the expense of which will be many times justified by the consequent saving in repairs to equipment and track, as well as the saving due to the increase in tractive power of the locomotives. With a refinement of design along these lines, it is altogether possible to construct reciprocating parts approaching in lightness 1/240 part of the total weight of the locomotive in working order, instead of 1/160 part as expressed in the previously mentioned general rule representing a fair average. With an increased tendency toward these very light parts, the percentage of parts balanced or unbalanced becomes less and less a factor. Greater efficiency is thus given to the locomotive, in that more and more of the weight allowable on the rail will be used in starting and pulling the train.

Your committee wishes to acknowledge its indebtedness to members of this Association, and others, who have furnished data; to the *Railway Age Gazette*, for the use of data contained in an article published therein by H. A. F. Campbell; and to Mr. George R. Henderson, who kindly offered his services to the committee; all of which assisted greatly in the preparation of this report.

S. G. Thomson, Chairman,
S. M. Vauclain,
F. J. Cole,
John Purcell,
W. H. V. Rosing,
O. C. Cromwell,
T. W. Heintzleman,
Committee.

The President: Gentlemen, you have heard the report. What is your pleasure?

Mr. Dunham: I move that the report be received and opened for discussion.

Motion seconded and carried.

Mr. D. D. Arden (S. & S. R. R.): I would like to ask, Mr. President: Were those data based on both inside and outside connected valve motion?

Mr. Thomson: The tests that were made and mentioned on Plate 1 were made on a series of Atlantic-type locomotives, all of which had the outside Walschaert gear, but the general conclusions were drawn from data shown on Plate 2 and from other information which the committee could gather.

Mr. Haig: Much of the information presented in the report bears on the reduction of weight of reciprocating parts. Reference to light parts makes the strength of material a pertinent factor in the discussion of this subject as presented by the committee. I fully agree that there is benefit to be gained by building light reciprocating parts and in the consequent reduction of the counterbalance weights in the wheels. Before we decide on the weights best suited for balancing, we must determine upon parts of ample strength. If we can get material which will justify the parts being light, it will then be practical to design them of smaller size, but to do this and at the same time prevent engine failures, the material must be durable. Material is available which has been made according to rigid specifications and which will stand required tests, but it does not always prove to be durable in service.

Reference was made to the light parts of locomotives built in 1914. Some locomotives built in that year have already had some of their parts break, and it would be interesting to find out to what extent there have been breakages of some of the parts of other engines investigated by this committee. Many locomotives built by the builders are required to be recounterbalanced after they have reached the various railroads. I know it to be a fact that some locomotives which have been recounterbalanced according to the two-thirds method have given much more satisfactory service after having been recounterbalanced according to this method. Because of my experience in this, it occurs to me that balancing only one-half of the weight of the reciprocating parts is too little. I do not believe that balancing only one-half of the reciprocating parts will provide as good a riding engine as one balanced by the two-thirds method.

The President: Are there any others who would like to speak on this subject?

Mr. Symons: Mr. President, I note this report is confined to two-cylinder locomotives, which prompts me to ask if the chairman will not kindly, in his closure, or at his pleasure, state if he feels so disposed, as to what would be the comparative result, or how near the disturbing influences in an engine counterbalanced

under this formula would approach to or compare with a similar weight of locomotive of the four-cylinder balanced type.

I have in mind the four-cylinder balanced engine as being very easy on the track and also on its contained parts, on account of the very small amount of counterbalance being necessary, as the engines balance each other, and this prompts me to ask if an engine balanced according to this formula, a two-cylinder engine, would approach closely the performance of a four-cylinder balanced engine, with reference to itself and the superstructure which carries it.

MR. ELMER: Mr. President, I see from the paper that the committee recommends the application of the counterbalance at a point directly opposite the crank pin. It is my understanding that in some quarters it is the practice to slightly advance the counterbalance, so that it is not at a point directly opposite the crank pin.

MR. YOUNG: In reference to the point raised by Mr. Haig relative to the failure of parts which have been very materially lightened over previous practice — looking at Plate No. 2, we have a large number of high-speed passenger engines, as shown on line 74, in which the relation of the weight of the locomotive to the weight of the reciprocating parts is 230.

In order to obtain as high a figure of the weight of the locomotive to the weight of the reciprocating parts, I believe it is necessary to heat-treat the reciprocating parts. On these engines the piston rods are hollow, the pistons are rolled steel, the crossheads are made light by the use of electric cast steel, there is a hollow crank pin, and the lever is attached directly to the crank pin, with the union member attached. These have been in service now almost two years, and we have not received in our department a record of any broken parts so far which have been used under somewhat higher vibration stress and heat-treated. There is a great deal of lightening accomplished by design, of course, in that hollow rods and pins are used, and there was a design of crosshead which was very light for its bearing area. I believe that the members can very safely lighten up the parts, both by design and material, if the material is closely supervised when it

is being treated. I believe it would be rather disastrous, however, if close supervision over the heat treatment is not given to the material, and probably you would have some disagreeable results. That has been, I believe, the experience of some of the roads.

MR. PILCHER: Mr. President, in connection with this question, I have in mind an investigation I made some years back of a peculiar knock that occurred on an engine on which the reciprocating parts were very heavy. In making the investigation, the curve of the piston load was plotted from indicator cards at the same speed; a corresponding pressure curve for the reciprocating parts was laid out, and we discovered that the first three engines in the stroke at that particular speed the crank pin was pulling the reciprocating parts. That is, the curves crossed at three inches of travel. That illustrates the possible effects of the very heavy reciprocating parts and the necessity for reduction. Of course, that is an example of how not to do it.

THE PRESIDENT: Are there any others who would like to discuss this question?

MR. MACBAIN: I move that the discussion be closed and the chairman have a chance to make some closing remarks.

MR. THOMSON: In regard to making the parts lighter, I do not think anybody will question this at all, if they have a chance to study the figures on Plate 2, particularly in the last column, which show what has already been accomplished in improving the ratio between the total weight of reciprocating parts and the total weight of the locomotive. On the locomotives to which Mr. Young referred this ratio is 230. The committee recommended 160. Personally, I would rather see that figure 180. I think any type of locomotive to-day could be designed to have the total weight of its reciprocating parts well within 1-180th part of the total weight of the locomotive, without spending much extra money on refinements, but the committee thought that in order to be very conservative they would make the figure 1-160 part, to represent good average conditions. If you will note in the last column, that figure does just about represent average conditions. The figures vary on freight locomotives built before 1904 from 203 down to 144, and on freight after 1904, 199 to 134. Now, any

one building a freight locomotive with the reciprocating parts weighing around 1-134th part of the locomotive is going to have trouble, regardless of how much they try to counterbalance it. With the passenger locomotives you will see that the figures vary from 1-241st to 1-147th, so that 1-160th is very, very conservative. Personally, I would like to see it 1-180th for existing locomotives, as stated before, and 1-200th for the building of new locomotives. Such figures will not require exceptionally light parts or the use of very high-grade material. When you get up to 1-240th then you do have to use high-grade, heat-treated material, and have to resort to the very best designs. But, gentlemen, I believe it can be done, and done very profitably to the railroads.

Think over the idea of bringing a locomotive into this world for twenty years with such heavy arms and legs that it continually gets tired and wears itself out. It costs the company a lot of money when you require this poor engine to reverse a surplus of avoirdupois at the rate of six times a second for twenty years. And we wonder why they are always loose and out of repair. Three or four or five hundred extra dollars well spent, when you are spending $20,000 to $25,000, is a mere nothing, when you come to think of it; and you won't have to spend $500 to get the advantage of many of the refinements attained in the automobile industry. They are getting the very best results from high-grade, heat-treated material. We can, too.

I believe that every penny is well spent in the refinement of the reciprocating parts, even if you get down to the finest detail and fight the thing down to the last inch. When you get the piston down to weighing around 100 lb., and the crossheads around 200 lb., and the total reciprocating parts not weighing more than 1100 or 1200 lb., or even lower than that, then you are accomplishing something. If you get down around these figures, it does not make very much difference what proportion of the parts you balance; your engine is going to ride fairly well. But when you get up around 2000 or 3000 lb. and have to begin to place counterbalance bobs on the axles because you can not get the extra weight into the wheels, it is ridiculous, gentlemen, and can be greatly improved.

It is wrong to bring new engines into existence in such condi-

tion, as I said before, and I do not think the matter of whether or not we should use heat-treated parts should have entered our heads. Neither do I think that, within reason, the cost should have entered our heads. It is a matter of only a few dollars, when you are spending thousands. It is an investment that will pay for itself the first two or three years you bring the locomotive back into the shop for general repairs. Many of you who have ridden locomotives going at 70 or 80 miles an hour can realize what it means to reduce those parts, so that this contention about our not being able to get results with heat-treated steel and refinement of parts, I do not think should be considered.

Reference was made to the balancing of the four-cylinder engine not being included in the report. We mention on the first page that the three and four cylinder engines would not be included because their parts more or less balanced each other. The two-cylinder locomotive is the hardest problem. I do not know whether you can get any two-cylinder engines to run as nicely as you can a three or four cylinder engine. The committee considered this matter carefully. When you get down into the refinements of balancing three-cylinder and four-cylinder engines there is a lot of little things which come in which are very, very complicated — cross-balancing and the care necessary to provide for a great many combinations that occur, etc. The committee thought, therefore, that it could not be brought in here, but should rather be made a subject of special papers. It would bring in a great deal of technicality and refinement, all of which we tried to exclude from the report. We thought, therefore, that it would be best to cover the hardest problem, which is the two-cylinder locomotive.

Mr. Elmer spoke about our recommending that the balances be directly opposite the crank pin. I do not understand that this was included in any way in the report, any more than just approximately showing the opposite position of the balance in the diagrammatical sketches on page 2. I do not think there is any objection to the placing of the balance at a slight angle to get certain refinements and results, if that is thought necessary.

In regard to the vibration and knock often found in an engine, this is not always due to the counterbalancing. There are a

great many other things that make an engine rough besides faulty counterbalance. If the wedges are loose, the engine will be very rough, and the higher the speed the worse it will be. The question of preadmission, lead and lap, and the cushioning of the parts, are all very pertinent to the subject of smooth riding, but it all resolves itself back again to the fact that the important thing is to make your parts light — that is the fundamental principle of the report this year. The report has given to you a new measure: the total weight of the reciprocating parts to be not more than 1-160th part, or, as I would prefer, 1-180th part of the total weight of the locomotive. This establishes a new ratio in counterbalancing, which I believe could be used very satisfactorily by everybody. To prove to yourself or to others whether it is right or not, it will be necessary to make experiments with this ratio, but the important thing is to get the parts as light as possible, so that the 1-180th will gradually improve to 1-200th and 1-220th. If this is done, I am sure that the counterbalancing problem will be fairly well eliminated.

THE PRESIDENT: We will now have the report of the Committee on Maintenance and Operation of Electrical Equipment, Mr. C. H. Quereau, chairman.

Mr. Quereau presented the report, as follows:

REPORT OF COMMITTEE ON MAINTENANCE AND OPERAATION OF ELECTRICAL EQUIPMENT.

To the Members:

In order that the members may have an adequate idea of the extent to which steam railroads have electrified, a table, corrected to January 15, 1915, has been prepared. Summarized, it shows electrification on parts of fourteen steam railroads, to the extent of 591.3 route miles, including 1761.65 miles of track. While this constitutes a very small percentage of the total steam railroad mileage, the figures probably exceed most of the informal estimates made by motive power officials, and to this extent they are impressive.

The table shows that for nearly ten years electricity has proved its ability to handle successfully a heavy and exacting traffic and the experience gained has demonstrated the fact that the only question to be settled for farther electrification is "Will it pay?" This is a question which can be wisely answered only by a detailed study of each problem proposed, made by competent electrical engineers.

It is quite possible some of the members who study Table I will wonder if they may be called on to maintain electric equipment in the near future, and if so, whether they should hesitate to assume the responsibility. In answer to this it may be said that all of the members of the committee making this report are responsible for the maintenance of electric equipment on steam railroads and that four of them acquired their experience in the steam motive power department. In general, the committee considers that experience in maintaining steam equipment is the best possible training for the new responsibilities, about the only additional requirement being an ability to understand and use intelligently the necessary electrical terms. This is not difficult.

Few Additional Facilities Required.

With the hope of being able to remove any possible doubt on this point there are submitted herewith outline drawings of shops designed and built by two steam railroads especially for the maintenance of their electric equipment, together with lists of the machine tools with which those shops have been provided. These lists appear in Tables II and III in the appendix.

A study of the shop plans which are presented will show that they are equally well adapted to the repairs of either steam or electric equipment; and the list of tools will convince the student that almost all of these are necessary in any event for the maintenance of steam equipment alone. If this belief is well founded, it should convince the most skeptical that no master mechanic who is successfully maintaining steam rolling stock need hesitate to undertake the maintenance of electric equipment.

The following statement from the superintendent of motive power of an important eastern steam railroad which has considerable mileage which has been electrified outlines the extent of the increased facilities which were involved by the electric operation:

"The maintenance of the MP-38 electric motor cars is handled by the .... shop of the ....Railroad. The only important machine they have in use that is not available at the shops is an armature-winding and field-coil-winding machine.

"At .... Shops, which handled the assembling and the subsequent repairs to the multiple unit cars on the .... Railroad, the only additional machine required by the electric car work was a journal-truing lathe to repair both inside and outside bearings on the motor truck axles without having to dismount the wheels. We also built a few wooden frame light Gantry hoists for use in applying the motors to the motor trucks. These hoists were made to span the erecting shop tracks on which the work was done and were required because this shop had no overhead crane facilities. The armature work required on the .... cars is done on a wooden horse and in a standard engine lathe. A testing transformer was also provided at ....together with a certain miscellaneous equipment of lifting hooks, chucks and clamps, which do not deserve listing separately.

"As to changes made in shop facilities other than tool equipment, the following list describes what was done at ....:

"1. An extension of the electric third rail along one track through the shop yard leading to the transfer table. This provides for moving electric locomotives under their own power to and from the shop. They are shifted on and off the transfer table by means of a hauling drum and snatch block which are part of the transfer table equipment.

"2. The door openings of six of the erecting shop tracks were widened to admit the electric locomotives, whose cabs are considerably wider than those of the steam locomotives. This was a special condition required by the old shop.

"3. No changes were made on account of the work done in assembling the MP-38 cars for the .... Rapid Transit service. It was necessary, however, to handle a certain amount of this work, especially about the motor trucks, with the traveling cranes in the locomotive erecting shop, which is just across the transfer table from the car shop in which these cars were assembled. If no such locomotive shop facilities were available, it would have been desirable to install overhead crane service for a certain number of the car shop tracks. The .... Shop at .... is equipped with an overhead traveling crane and other hoisting facilities for the maintenance work on these cars.

"At ...., it was necessary to build an additional new inspection shed or shop close to the electric train terminal so that the running inspection of the cars would be economically done. This shop has pits with the rails elevated about 12 in. above the floor, has overhead crane facilities, steam heat, is piped with compressed air, is wired for electric light and power, and has a small blacksmith shop and machine shop equipment which handles all the maintenance of the electric equipment on the cars. Much of this work was originally done at .... Shop and the machinery is the ordinary shop equipment that was formerly used at .... and later moved to .... as our experience grew. None of it outside of some chucks, clamps and similar minor articles, could be considered as required specially by the multiple unit cars.

"The wheel and axle work and other heavier mechanical maintenance is handled at .... Shops with the equipment formerly used for steam cars and locomotives.

"In this description it is assumed that the relation of .... Shops and .... Terminal proper is understood, the two being only 2.4 miles apart and under the same division management."

In connection with the experience with electrification, the following list shows the additional tools which were found necessary for handling the electric equipment at the shops of that company, which was originally equipped only for the maintenance of steam equipment:

Portable Hydraulic Press, made with 21-in. cylinder and 12-in. stroke, using a water pressure of 1100 lb., which is capable of exerting a pressure of 190 tons. This press is used in removing crank pins from discs, and discs from motor shafts.

Hook for Lifting Front End of Locomotive.—This hook is used in raising the front end of Class DD-1 electric locomotives, engaging under the breast beam, and has a toe to prevent slipping.

Lifting Beam for Motors.—It is necessary to have a lifting beam for removing and replacing motors, and this consists of a steel plate beam having two arms arranged at the proper distance for lifting the motors by the crank pins in the discs.

Lifting Beam for Removing and Replacing Cabs.—This is a very simple beam with two arms which screw on the lifting rods on the roof of the cab.

Special Chuck for Boring Bearings.—This chuck is used in boring jack shaft and motor bearings, and consists of a cast-iron sleeve cut in half, on the base of which is a projecting ring, which engages a groove in the face plate of boring mill, in order to centralize the work quickly.

Tension Device.—On account of re-banding armatures, it was necessary to get a special tension device used in connection with this work. The armatures are all banded on a driving wheel lathe, and this machine is placed conveniently in order to maintain a constant tension on the banding wire, the tension being indicated on a scale in pounds.

Insulation Testing Transformer.—This consists of a 3-kw. transformer mounted on a truck with voltmeters for testing from 200 to 6000 volts, and is used for testing armatures and fields for grounds. This machine was purchased.

Cradle for Holding Armatures.—It was necessary for us to build a cradle for holding the armatures after removing them from the locomotives when it is not necessary to work upon them.

Referring to the above list the master mechanic at .... says: "This covers about all the special tools which we have found necessary to take care of the electrical work. The manner in which the electric equipment is handled is exactly the same as that in which we handle any other equipment."

Maintenance Organization for Electric Equipment.

A feature worthy of note in connection with the maintenance of steam and electrical equipment will be found in the comparatively small machine tools and light cranes installed in electric locomotive repair shops. The reason for this is the relative lightness of the individual parts of the electric locomotives. Another feature is that, on the average, the age of the employees in an electric equipment shop is less than in a steam equipment shop. One reason for this is that the maintenance of electric equipment on steam roads is a comparatively new business, and has been in existence too short a time to have employees grow old in the service. It is undoubtedly true that the older men are more awed by the, to them, unknown problems of electricity, and they prefer the security of their old positions, which they are sure of filling capably, to the uncertainty of what they consider a new field. On the other hand, the fact that the new positions are connected with electrical apparatus appeals to the imagination of the younger men, who have less to lose and more to gain

in the new work. The fact that younger men are attracted is not a disadvantage.

One might easily assume it is essential the workmen have a rather extensive electrical training, and it is true that a maintenance organization should have one or two electrical experts, mechanics rather than engineers. However, experience has shown that at least 90 per cent of the work to be done and of the problems to be solved are mechanical.

Those who are particularly interested in the organization and methods of maintenance of the Long Island Railroad electric equipment will find an article in the *Electric Railway Journal* for June 10, 1911, which gives in detail the organization and methods of inspection and maintenance on that road. In this connection it is worth noting that, aside from the inspection, the maintenance is taken care of in the regular steam railroad repair shops.

There is this characteristic difference between steam and electric equipment. With steam locomotives it takes about five minutes to locate a defect and from a day to a week to make repairs; with electric equipment it takes an hour or two to locate the cause of the trouble and from five minutes to a day to repair the defect.

A detailed discussion of maintenance methods would be unprofitable at this time, as there are no acknowledged standard methods, the practice varying necessarily with the design of the equipment, operating conditions and the policy of the responsible officer. The slotter, the lathe and other machine tools are used in the same way whether the work is for an electric locomotive or a steam locomotive.

Standards, in design, however, have been established for clearance lines, both for equipment and permanent way structures. These have been adopted as recommended practice for third-rail and overhead working conductors by the American Railway Association, Circular 1496, and by the American Railway Engineering Association, Vol. 15, 1914, as well as by the American Electric Railway Association.

Operation of Electric Equipment.

At the time of introduction of electric operation on any railroad, the usua plan is to qualify the regular steam locomotive engineers and firemen for service on the electric locomotives. A few days' instruction by a qualified traveling engineer and a few trips over the road under his supervision are sufficient. To those without the experience, this statement may appear fanciful, but as a matter of fact it may be accepted without question.

A little consideration will convince even the most skeptical that a knowledge of the Book of Rules, the significance of signals and train orders, experience in handling the air brakes and an intimate knowledge of the territory constitute at least nine-tenths of the qualifications of an efficient engineman. These are the same for electric and steam operation. No experienced railroad official would hazard his reputation on the statement that sufficient experience in these essential qualifications could be acquired in a month or even in a year. On the other hand, many division superintendents and mechanical officials have qualified hundreds of their steam enginemen to operate safely and suc-

cessful y their most important trains with electric equipment, the time required per man not exceeding a week.

This statement should not be construed as meaning that the motorman, when first qualified, was as competent as after a longer experience, but that he can "safely and succesfully" operate the most important trains.

The operation of electric equipment is much simpler than for steam locomotives. The motorman does not have his vision blinded or confused by smoke or steam, coal dust or ashes; his attention is not distracted by watching the steam gauge or water glass, or instructing his fireman in his duties, nor is he bothered by balking injectors, ash pans or leaky flues. There are, of course, no stops for coal and water and there need be no long wait between trains for cleaning fires or ash pans.

Operating Records.

Numerous statistics relating to electrically operated roads have been published, including the cost of labor and material expended in repairs, and to the efficiency of the apparatus and the maintenance methods as shown by the number of delays. Several of these statements use as a basis for judging the efficiency of the equipment and its maintenance the unit "Miles per Detention," and also the unit "Miles per Minute Detention," but the majority of the statements published do not show the former item.

For the operating officials the unit "Miles per Minute Detention" is of decided value, but this is not the proper basis on which to judge the efficiency of the apparatus nor of the force that maintains it, because the length of the delay is affected in most cases more by operating conditions than by the nature of the failure originally causing it.

A few illustrations will probably make the point much more clear than an extended argument. In three cases on one electrified road detentions due to broken tires were respectively 38 minutes, 60 minutes and 92 minutes. Inasmuch as the length of the train delay due to the single class of failure varied from thirty-eight to ninety-two minutes, it makes the unit "Miles per Minute Detention" of absolutely no use to the superintendent of electric equipment. The fact of importance to him and to those who are interested in the efficiency of the equipment is that the tires broke. Including the length of the delay only confuses matters.

To cite another case: A certain train was delayed 54 min., because the contact shoe lead was burned or broken off and the train lay until a following train was coupled in the rear, which then had difficulty in starting the train. In this connection the fact that interests the superintendent of electric equipment is not the 54 min. delay, but the fact that the contact shoe was burned or broken off and that the motorman used poor judgment in holding his train when he might have tied up the shoe leads or removed the shoe fuses. But, to the division superintendent the unit "Miles per Minute Detention," if properly followed up, would have developed the fact that the length of the delay was unnecessary.

It appears to be advisable, therefore, to consider only the unit "Miles per Detention" in connection with the records of the maintenance department,

and it seems also to be desirable to subdivide the causes of train delays due to electric equipment under three headings: "Man Failures," "Electrical" and "Mechanical." The headings "Electrical" and "Mechanical" are self-explanatory. The heading "Man Failures" is intended to cover failures of equipment which are due to the men operating it. Examples may be cited as follows: A delay of eight minutes because of blown shoe fuses on the locomotive was caused by picking up a piece of wire that had been left on the right of way; a train was delayed five minutes because a heater fuse blew and one of the train crew pulled the main switch, which was not necessary; a train was delayed four minutes because the yard inspector did not replace the jumpers between cars after completing his work on these cars.

Obviously, such items as these should not be included in the statistics by which either the equipment or the force responsible for maintaining it are judged, although they should be included in the delay statistics for the benefit of the division superintendent and other operating officials.

SUMMARY.

The foregoing report may be briefly summarized as follows:

Table I shows that in the ten years from 1895 to 1905 there were two steam railroads electrified to the extent of 88.17 route miles and 216.91 track miles. In the ten years following 1905 there were twelve steam railroads electrified to the extent of 503.13 route miles and 1544.74 track miles.

The committee is convinced, and has attempted to show, that no official who is successfully maintaining steam equipment need hesitate to undertake the maintenance of electric equipment, and that a shop layout satisfactory for maintenance of electric equipment is well adapted to the maintenance of steam equipment and vice versa.

The committee considers that the plan of qualifying steam locomotive enginemen as motormen for electric equipment is the safest, most efficient and fairest method, and that the operation of electric equipment is simpler and less exacting than of steam equipment.

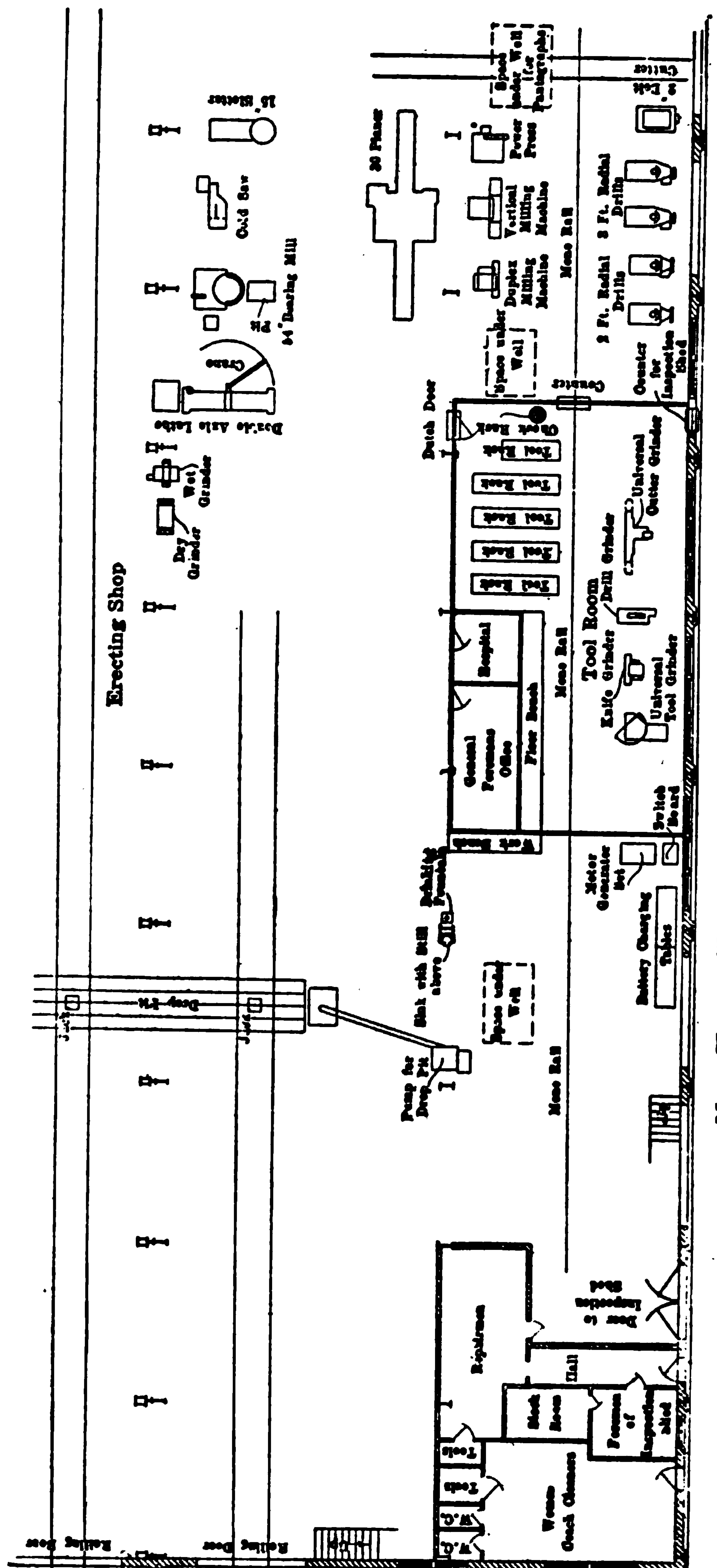
The committee recommends that the statistics by which the efficiency of electric equipment and the force responsible for its maintenance are judged should be based on the unit "Miles per Detention."

The committee recommends further that the statistics giving the train delays due to failures of electric equipment should be grouped under three headings: "Man Failure," "Electrical" and "Mechanical," and that the delays under the heading "Man Failure" should not be included in compiling statistics from which the efficiency of the equipment and the maintenance organization are to be judged.

NOTE.—The committee is greatly indebted to the *Electric Railway Journal* for the use of its electrotypes in illustrating this report.

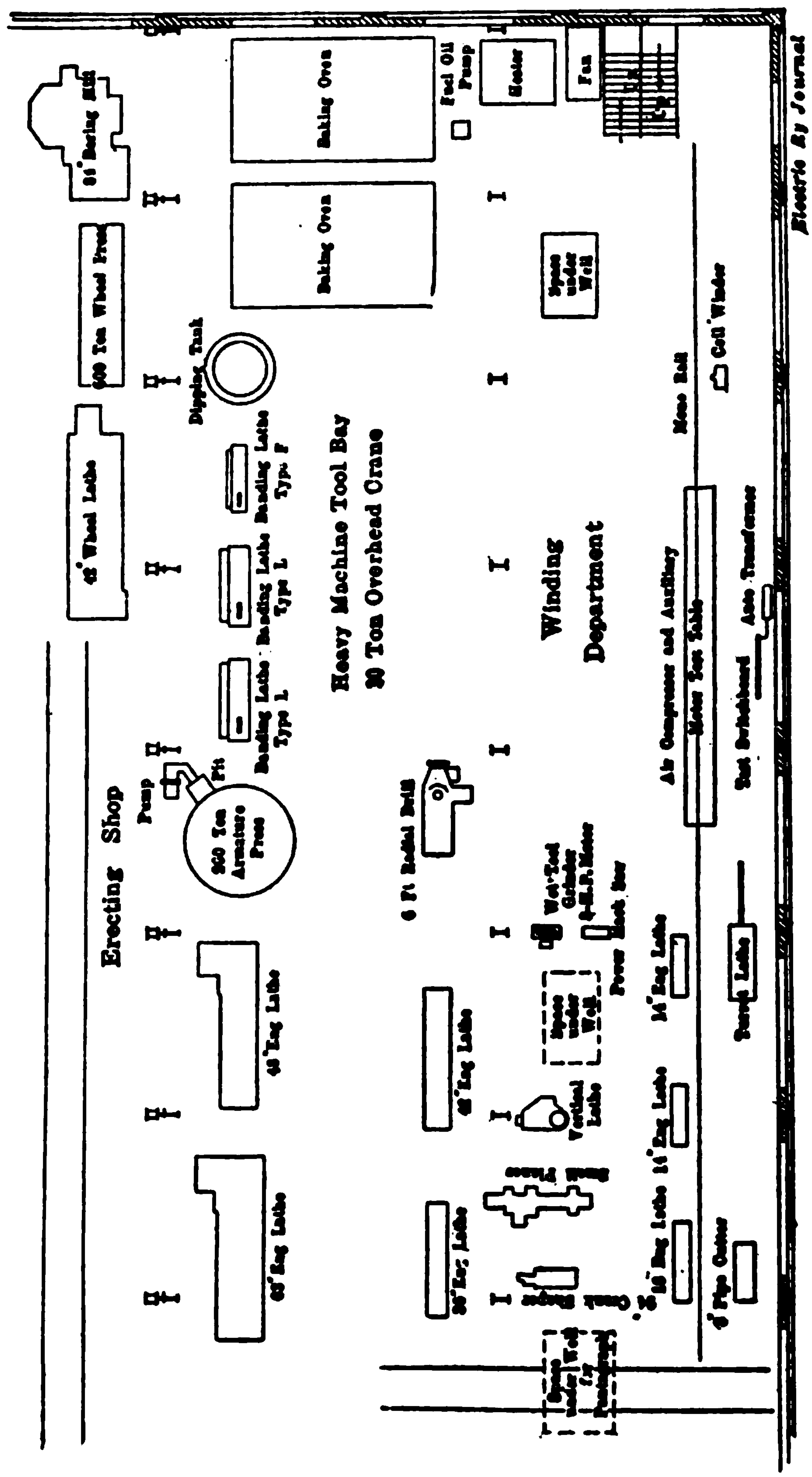
C. H. QUEREAU, Chairman,
G. C. BISHOP,
G. W. WILDIN,
J. H. DAVIS,
R. D. HAWKINS, *Committee.*

New Haven Shops—General Arrangement of Existing and Future Buildings



New Haven Shops—West End of Machine Shop

Harmon Shops—Plan of Main Shop Building, Showing Arrangement of Various Departments



New Haven Shops—East End of Machine Shop

New Haven Shops—View from East End of Light Machine Tool Bay.

Harmon Shops—Interior View of Machine Shop.

New Haven Shops—Cross-Sectional Elevation of Main Building

APPENDIX.

TABLE I.

PRINCIPAL STEAM ROAD ELECTRIFICATIONS IN AMERICA

NAME OF ROAD AND SECTION ELECTRIFIED	Began Elec. Operation	Length of Route, Miles	Length of Track, Miles	System of Electrification	Number Locos.	Car Equipment	
						Motors	Trail
B. & O., Baltimore, Md., Baltimore Tunnels...	1895	3.75	8.4	675 V. D. C..........	9	....	....
Long Island Ry..........	1905	84.42	208.51	600 V. D. C..........	....	474	78
New York Central, Harmon, New York.......	1906	54	255	600 V. D. C..........	63	192	19
New York, New Haven & Hartford R. R., N. Y., New Haven..........	1908	99.61	537.94	Single Phase 11,000 V. 25 Cyc. 600 V. D. C., N. Y. C..........	100	74	79
Grand Trunk Ry., St. Clair Tunnel Co., Pt. Huron, Mich., St. Clair Tunnel..........	1908	4	12	Single Phase 3300 V. 25 Cyc..........	3 Units....	....	....
Great Northern R. R., Cascade Tunnel, Washington..........	1909	4	10	Three Phase, 6600 V. 25 Cyc..........	4	....	....
Michigan Central, Detroit River Tunnel, Detroit, Mich..........	1910	4.4	25.7	600 V. D. C..........	10	....	....
Penn. Tunnel & Term. R. R., P. R. R. into N. Y. City..........	1910	19.9	98.6	600 V. D. C..........	68	68	....
B. & M. R. R., No. Adams, Mass., Hoosac Tunnel..........	1911	7.92	22	Single Phase, 11,000 V. 25 Cyc..........	5	....	....
Butte, Anaconda & Pacific R. R., Butte-Anaconda, Mont..........	1913	30	90.5	2400 V. D. C..........	19 Frt., 2 P	....	....
Norfolk & Western R. R., Bluefield-Elkhorn, W. Va..........	Bldg. 1914	30	75	Split Phase, 11,000 V. 25 Cyc., A. C...	12	....	....
Canadian Northern, Montreal, Can..........	Bldg. 1914	9	25	2400 V. D. C,..........	6	8	....
Pennsylvania R. R., Philadelphia to Paoli......	Bldg. 1914	20.3	93	11,000 V. A. C..........	....	93	....
C. M. & St. P..........	Bldg. 1915	220	300	3000 V. D. C..........	21	....	....

Abbreviations: V.—Volts. D. C.—Direct Current. A. C.—Alternating Current.

TABLE II.

Tools Used in Van Nest Shop of the New York, New Haven & Hartford Railroad.

1 90-in. Driving Wheel Lathe.
1 42-in. Coach Wheel Lathe.
1 100-in. 600-ton Hydraulic Wheel Press.
1 Double-head Axle Lathe.
1 Combined Punch and Shear, 36-in. Throat.
1 1250-lb. Steam Hammer.
1 42-in. Band Saw.
1 Combination Saw Bench.
1 Double Surfacer.
1 Combination Mortiser and Borer.
1 Single Spindle Reversible Shaper.
1 20-in. Jointer and Planer.
1 24-in. Patternmaker's Lathe.
1 3-spindle Combined Vertical and Radial Borer.
1 75-lb. Steam Driven Hammer.
1 2½-in. Forging Heading and Upsetting Machine.
1 Case Hardening Furnace.
1 Bolt Furnace.
1 Cutter and Reamer Grinder.
2 24-in. Water Tool Grinders.
2 Dry Grinders.
1 Sellers Universal Tool Grinder.
1 Automatic Knife Grinder.
1 22 by 22 in. by 5-ft. Planer.
1 36 by 36 in. by 12-ft. Planer.
2 24-in. Pillar Shapers.
1 15-in. Vertical Slotting Machine.
1 Vertical Milling Machine.
1 Duplex Milling Machine.
1 Universal Milling Machine.
2 24-in. Plain Radial Drill Presses.
2 30-in. Plain Radial Drill Presses.
1 24-in. Sensitive Drill Press.
1 72-in. Full Universal Radial Drill Press.
1 52-in. Boring Mill.
1 84-in. Boring Mill.
1 Plain Inclinable Power Press.
1 Buffing Lathe, Column Type, Double-head.
3 Double McCaslin Forgers.
1 Triple Valve Test Rack.
2 14-in. High Duty Engine Lathes.
1 16-in. Toolmaker's Lathe.

2 18-in. Engine Lathes.
1 36-in. Engine Lathe.
1 42-in. Engine Lathe.
1 48-in. Engine Lathe.
1 60-in. Engine Lathe.
1 2½ by 26 in Flat Turret Lathe.
1 24-in. Vertical Lathe.
1 Motor Generator and Switchboard for Storage Battery Charging.
1 Grindstone and Frame.
1 Twist Drill Grinder.
1 Double-head Bolt Cutter.
1 Pipe Threader and Cutter.
1 Cold Saw Cutting-off Machine.
1 Metal Band Saw.
1 Power Hack Saw.
1 6-ft. Squaring Shear.
2 60-ton Cranes.
1 30-ton Crane.
2 1½-ton Monorail Hoists.
1 5-ton Pneumatic Crane.
4 Canton Portable Cranes.
1 Special 6-in. Slotter for Finishing Brush Holders.
1 Cincinnati Cutter and Reamer Grinder.
1 Complete Small Tool Equipment, Air Motor, Electric Drills, Air Hammer, etc.
1 Babbitting Furnace with Babbitting Table from New Haven Design.
1 Besley Disc Grinder.
1 Electric Riveter.
1 Electric Welder.
1 Cutting-off Machine for High Speed Steel, Copper and Tubing.
1 4-in. Centering Machine.

Special Electric Tools.

1 270-ton Armature Press.
1 Type L Banding Lathe.
2 Type K Banding Lathes.
1 Hydrogen Gas Generator, Storage Battery Work.
2 Power Taping Machines.
1 Internal and External Special Milling Machine for Cutting Dovetails in Field Castings and in Armature Spiders for Laminations.
1 Coil Testing Machine.
1 Armature Testing Machine.
1 Motor Generator Set, Transformer, Switchboard, etc., for Testing Auxiliary Apparatus.
1 Pinion Puller.

2 Baking Ovens from New Haven Design.
1 Dipping Tank large enough to take largest Motor for Dipping Armatures and Fields.
1 Power Driven Coil Winder.

TABLE III.

Machine Tools Used in Harmon Shop, New York Central Railroad Company.

1 60-in. Old-style Driving-wheel Lathe for Banding Armatures.
1 60-in. Radial Drill Press.
1 36-in. Plain Drill Press.
1 4-spindle Sensitive Drill.
1 Grindstone.
1 51-in. Vertical Boring Mill.
1 Car Wheel Borer.
1 500-ton Wheel Press.
1 30-in. Planer.
1 24-in. Shaper.
1 Center-drive Axle Lathe.
1 30-in. Patent Head Engine Lathe.
1 Centering Machine.
1 Bolt Drilling Machine.
1 Single-head Bolt Cutter.
1 Double-head Bolt Cutter.
1 15-in. Drill Slotter.
1 Large Punch and Shear, 36-in. Gap.
1 24-in. Engine Lathe.
1 16-in. Engine Lathe.
1 1100-lb. Single Frame Steam Hammer.
2 McCaslin Improved Blacksmith Forge.
1 36-in. Band Saw.
1 24-in. Rip Saw.
2 8-gal. Babbitt Kettles.
1 500-ft. Air Compressor.
2 150-kw. Generators for Light and Power.
3 18-ton Traveling Cranes.
1 6-ton Telpher Crane.
1 40-ton Hydraulic Jack.
1 75-ton Hydraulic Jack.

Mr. Quereau: As a matter of general information, I will say that I am connected with the division where all train detentions amounting to two minutes are counted, whether the delay is made up or not. On the division I am connected with we have had no steam failures for eight years.

The thought of the committee is that it is no benefit to the superintendent or the responsible officer if the delays for which the equipment itself is not responsible are included in the statistics from which the judgment is made as to the efficiency of the apparatus or the men maintaining it.

THE PRESIDENT: Gentlemen, you have heard the report of this committee. What is your pleasure concerning it?

MR. PURCELL: I move that it be received and opened for discussion.

Motion seconded and carried.

THE PRESIDENT: Is there any discussion?

MR. PRATT: On account of being a little bit behind our schedule time, it is likely that the discussion on this most important paper will be limited, and perhaps most of us do not feel competent to discuss it from our experiences. However, I think that the opportunity should not be passed to thank Mr. Quereau and his committee for this paper and the papers of this character that this committee has given this Association in the last few years. Probably it makes us feel a little bit more firm on our feet, with the impending electrifications, so that our knees will not wobble so much when we talk about it or think about them.

MR. WILDIN: I wish to draw Mr. Quereau's attention to a slight misstatement. Mr. Quereau says he did not have a boiler failure in eight years. My information and knowledge, so far as the New Haven road is concerned, is that we have renewed every boiler in the electric locomotives, and I think the New York Central has done the same.

MR. QUEREAU: May I interrupt — the question was the train detentions due to boiler failures.

MR. WILDIN: Since he has qualified the statement, I will let him off. I am a very close neighbor of Mr. Quereau's, and keep more or less in touch with him on these details.

I want to say this about the question of shops. While the matter is pretty well covered in the report of the committee so far as the New Haven shops are concerned, the section of our electrical shop at Van Nest is merely a 375-ft. section taken from

the large shop at Readville, Massachusetts, which is purely a steam locomotive shop, identical in construction, and I think is about as wide a variation from the usual custom of building electrical shops as any built so far.

In building this shop it was the contention of the electrical people interested in electrification, especially on our roads, that we should have purely a drop-pit proposition as a shop, and that it was impossible to handle electric locomotives with steam locomotive cranes the same as you do in steam locomotive shops. The contention was that the bodies of the locomotives were built so light they would not stand the strain, but I called attention to the fact that they lifted the body with four jacks, and my contention was if you could do that we could lift the body by putting four hooks on a crane, in the same position as the jacks, without injuring the body.

We think we have about the best electrical repair shop in the United States for electric locomotives. Of course, there is in our shop some very peculiar machinery, designed especially for the peculiar equipment we have on that road. I presume we have the most complicated electrical equipment there is in the United States — and for that reason, perhaps, we do not make as many miles per detention as some of our neighbors, but you must realize that we have both the alternating and direct current equipment to contend with, and we have more trouble from changing over from alternating current to direct current than in any other one particular feature of our operation, which would not happen if we had either system pure and simple.

For the benefit of the steam men who have not had any more electrical experience than I had when I took hold of the New Haven road eight years ago, when its electrification was just in its infancy, I will say that we had to pick many bugs out of that system. We have been good missionaries for the rest of the steam lines, and I suggest to those who are going up against electrification in these days, that they are not justified in approaching the subject with that fear and trembling which was common some years ago.

You will realize, when the electrical equipment is once designed, the engineering feature is completed, and it is a mere

matter of mechanical manipulation and of keeping the apparatus in shape and keeping it going. There is no reason why a man who is used to putting together two pieces of steel should not be able to put together two pieces of copper and put them back just as he found them. There is no great complication to it, and it is merely a matter of keeping the apparatus in working order.

THE PRESIDENT: Mr. Quereau, do you wish to say anything further?

MR. QUEREAU: I have nothing further to say. There is probably not time to discuss the matter, but we made a couple of recommendations as to statistical matters.

MR. WILDIN: I think there is one thing further we might have said in this report. It has occurred to me since the report was turned in, and that is this: We should first define what is going to be a detention. There is no use in saying we shall have so many miles per detention, unless we define whether the detention is to be one minute, two minutes or five minutes. Mr. Quereau has already, apparently, adopted two minutes as the period. Another man who wants to make a good record will make it five minutes, and I think there should be some clear understanding as to what we will start with as a basis.

THE PRESIDENT: I think, unless there is some objection, this matter should be referred to the Executive Committee and let them pass on it for next year.

MR. QUEREAU: That is a good way to dispose of the matter.

THE PRESIDENT: It will be so ordered, unless there is objection, that the matter is referred to the Executive Committee.

Vice-President Pratt in the chair.

THE CHAIRMAN: The next business is the report of the Committe on Forging Specifications. Mr. C. D. Young, Engr. Tests, Penna. R. R., is chairman of the committee.

Mr. Young presented the report, as follows:

REPORT OF THE COMMITTEE ON FORGING SPECIFICATIONS.

To the Members

Your committee under date of October 24, 1914, issued Circular H, on Forging Specifications:

Criticisms were requested first on certain fiber stress figures to be used in heat-treated carbon and alloy steel materials for forgings. Replies to this

question developed that there was little information available covering the results of the use of this material and your committee is, therefore, not prepared to recommend final figures for proper stresses for these heat-treated parts. The committee feels that the following table expresses the maximum fiber stresses which should be used in this grade of material in the design and, therefore, presents it to the Association as information, suggesting that it be submitted as Recommended Practice and with the understanding that this subject will again be reviewed after more extended experience of the membership before considering it for advancement as a Standard of the Association:

	Heat-Treated Carbon		Alloy	
	Tension and Compression	Bending	Tension and Compression	Bending
Main and parallel rods.	10 000	14 000	12 000	17 000
Piston rods...........	11 000	15 000	13 500	18 000
Driving axles.........	....	20 000	....	24 000
Crank Pins...........	....	17 000	....	20 000

Second.—Your committee prepared a specification for alloy steel forgings of the chrome-nickel type. After consideration of the criticisms of this specification, and of the quenched and tempered carbon steel and alloy steel (chrome-vanadium type) specifications, the committee recommends the following:

(a) That the present standard specifications for quenched and tempered carbon steel axles, shafts and other forgings for locomotives and cars, page 510, 1914 Proceedings, be modified in accordance with the proposed specifications for quenched and tempered carbon steel forgings as submitted in Exhibit "A." This in order to harmonize this specificaton with our alloy steel specifications and also includes a recommended proof test.

(b) That the present specifications for alloy steel forgings, page 505, 1914 Proceedings, be modified as submitted in Exhibit "B." This change consists in adding to the present alloy steel specifications for chrome-vanadium, a chrome-nickel alloy and also a recommended proof test.

Your committee recommends that these be submitted to letter ballot as recommended practice.

Respectfully submitted,

C. D. Young, Chairman,
A. H. Fetters,
H. B. MacFarland,
J. R. Onderdonk,
H. E. Smith,
J. W. Taylor,
Frank Zeleny, *Committee.*

EXHIBIT "A."

STANDARD SPECIFICATIONS FOR QUENCHED AND TEMPERED CARBON STEEL FORGINGS.

1. **BASIS OF PURCHASE.**—These specifications are to cover the various classes of carbon steel forgings now commonly used in locomotive construction.

I. Manufacture.

2. **PROCESS.**—The steel may be made by the open-hearth or other process approved by the purchaser.

3. **DISCARD.**—A sufficient discard shall be made from each ingot to secure freedom from injurious piping and undue segregation.

4. **PROLONGATION FOR TEST.**—For test purposes a prolongation shall be left on each forging, unless otherwise specified by the purchaser.

5. **BORING.**—(a) All forgings over seven inches in diameter shall be bored, unless otherwise specified by the purchaser. The boring shall be done before quenching.

(b) If boring is specified, the diameter of the hole shall be at least 20 per cent of the maximum outside diameter or thickness of the forging, exclusive of collars and flanges.

6. **HEAT TREATMENT.**—For quenching and tempering, the forgings shall be allowed to become cold after forging. They shall then be uniformly reheated to the proper temperature to refine the grain (a group thus reheated being known as a quenching charge) and quenched in some medium under substantially uniform conditions for each quenching charge. Finally they shall be uniformly reheated to the proper temperature for tempering or "drawing back" (a group thus reheated being known as a tempering charge) and allowed to cool uniformly.

II. Chemical Properties and Tests.

7. **CHEMICAL COMPOSITION.**—The steel shall conform to the following requirements as to chemical composition.

Carbon	First class	0.38 —0.52	per cent.
	Second class	0.45 —0.60	"
Manganese		0.40 —0.70	"
Phosphorus	not over	0.05	"
Sulphur	not over	0.05	"

8. **LADLE ANALYSIS.**—An analysis shall be made by the manufacturer from a test ingot taken during the pouring of each melt, a copy of which shall be given the purchaser or his representative. This analysis shall conform to the requirements specified in Section 7.

9. **CHECK ANALYSIS.**—(a) An analysis may be made by the purchaser from a forging representing each melt, which shall conform to the requirements specified in Section 7. Drillings for analysis may be taken from a forging, or from a full-sized prolongation of the same, at any point midway between

the center and surface of solid forgings, and at any point midway between the inner and outer surfaces of the wall of the bored forgings, or turnings may be taken from a test specimen.

(b) In addition to the complete analysis a phosphorus determination may be made by the purchaser from each broken tension test specimen, and this determination shall conform to the requirements for phosphorus specified in Section 7.

III. Physical Properties and Tests.

10. **TENSION TESTS.**—(a) The forgings shall conform to the requirements as to tensile properties specified in Table 1.

TABLE No. 1.

For forgings whose diameter or thickness is not over ten inches when solid.

Size	Tens. str lb. per sq. in.	Elastic limit lb. per sq. in.	Elongation in 2 in. per cent.		Reduction of Area per cent	
			Inverse ratio	Not under	Inverse ratio	Not under
First Class Up to 7 in. outside diameter or thickness when solid, or 3½ in. max. wall when bored...	85 000	50 000	2 000 000 / Tens. Str.	20.5	3 800 000 / Tens. Str.	39
Second Class Over 7 to 10 in., incl., outside diameter or thickness when solid, or 5 in. max. wall when bored....................	85 000	50 000	1 900 000 / Tens. Str.	19.5	3 600 000 / Tens. Str.	37

(b) The classification by size of the forgings shall be determined by the specified diameter or thickness which governs the size of the prolongation from which test specimen is taken.

(c) Elastic limit shall be determined by means of an extensometer of a type the equal of the "Berry" strain gage.

(d) Test of forgings shall be made only after final treatment.

(e) The speed of the test machine shall not exceed ⅛ in. per minute until the elastic limit has been reached.

11. **BEND TESTS.**—If specified by the purchaser, bend tests shall be made as follows:

(a) For the first class by size, the test specimen shall bend cold through 180 deg. around a 1-in. flat mandrel having a rounded edge of ½ in. radius without cracking on the outside of the bent portion.

(b) For the second class by size, the test specimen shall bend cold through 180 deg. around a 1½-in. flat mandrel having a rounded edge of ¾-in. radius, without cracking on the outside of the bent portion.

12. **PROOF TEST.**—(a) Unless otherwise specified by the purchaser, all forgings shall be subjected to an impact proof test. The details of this test shall be agreed upon by the manufacturer and the purchaser.

(b) A recommended test for axles, shafts and similar forgings is as follows: Place the forging upon supports 3 ft. apart mounted on an M. C. B. drop test machine. The forging should then be struck two blows by a tup weighing either 1640 or 2240 lb. falling from heights proportioned according to the following formula and tabulation. Between the first and second blows the forging shall be turned 90 deg.

Height of drop in feet $= .01D^2$ for 1640-lb. tup.

Height of drop in feet $= .0073D^2$ for 2240-lb. tup.

NOTE.—$D =$ Diameter of shaft or thickness of forging at center in inches.

TABLE No. 2.

Diameter of Shaft at center, inches	Height of drop in feet	
	1640-lb. tup	2240-lb. tup.
5	1 ft. 3 in	0 ft. 11 in.
5½	1 ft. 8 in	1 ft. 3 in.
6	2 ft. 2 in	1 ft. 7 in.
6½	2 ft. 9 in	2 ft. 0 in.
7	3 ft. 5 in	2 ft. 6 in.
7½	4 ft. 3 in	3 ft. 1 in.
8	5 ft. 1 in	3 ft. 9 in.
8½	6 ft. 2 in	4 ft. 6 in.
9	7 ft. 3 in	5 ft. 4 in.
9½	8 ft. 7 in	6 ft. 3 in.
10	10 ft. 0 in	7 ft. 4 in.
10½	11 ft. 7 in	8 ft. 5 in.
11	13 ft. 4 in	9 ft. 9 in.
11½	15 ft. 3 in	11 ft. 3 in.
12	17 ft. 3 in	12 ft. 7 in.
12½	19 ft. 5 in	14 ft. 3 in.
13	22 ft. 0 in	16 ft. 0 in.
13½	24 ft. 7 in	18 ft. 0 in.
14	27 ft. 5 in	20 ft. 0 in.
14½	30 ft. 6 in	22 ft. 3 in.
15	33 ft. 9 in	24 ft. 8 in.

NOTE.—The above heights are to the nearest inch.

13. **TEST SPECIMEN.**—(a) Tension and bend test specimens shall be taken from a full size prolongation of any forging. For forgings with large ends or collars, the prolongation may be of the same cross section as that of

the forging back of the large end or collar. Specimens may be taken from the forging itself with a hollow drill, if approved by the purchaser.

(b) The axis of the specimen shall be located at any point midway between the center and surface of solid forgings, and at any point midway between the inner and outer surfaces of the wall of the bored forgings, and shall be parallel to the axis of the forging in the direction in which the metal is most drawn out.

(c) Tension test specimens shall be of the form and dimesions shown Fig. 1.

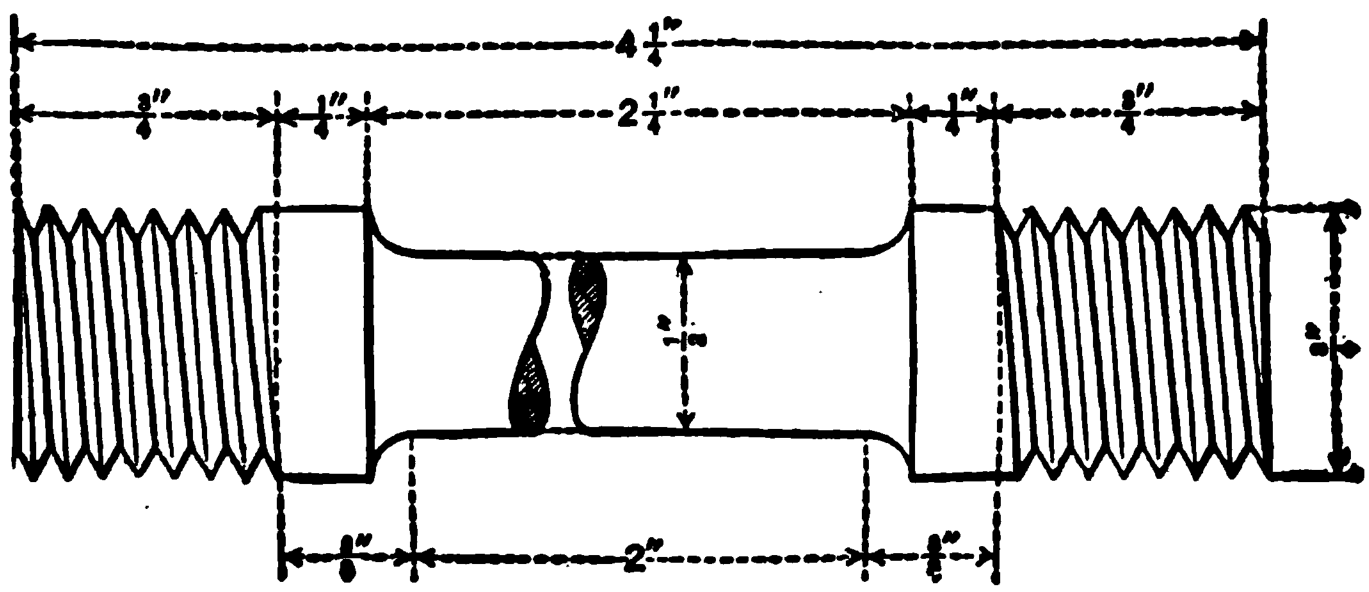


FIG. 1.

(d) Bend test specimens shall be ½ in. square in section with corners rounded to a radius not over $\frac{1}{16}$ in. and need not exceed 6 in. in length.

14. **NUMBER OF TESTS.**—(a) One tension, and if specified by the purchaser, one bend test shall be made from each tempering charge. If more than one quenching charge is represented in a tempering charge, one tension and, if specified, one bend test shall be made from each quenching charge. If more than one melt is represented in a quenching charge, one tension and, if specified, one bend test shall be made from each melt.

(b) If more than one class of forgings by size is represented in any lot, one tension, and if specified, one bend test from a forging of each class by size shall be made as specified in Sections 10, 11 and 13.

(c) If any test specimen shows defective machining or develops flaws, it may be discarded and another specimen substituted.

(d) If the percentage of elongation of any test specimen is less than that specified in Section 10 (a) and any part of the fracture is more than ¾ in. from the center of the gage length, as indicated by the scribe scratches marked on the specimen before testing, a retest shall be allowed.

15. **RETESTS.**—(a) If the fracture of any tension test specimen shows over 15 per cent crystalline, a second test shall be made. If the fracture of the second specimen shows over 15 per cent crystalline, the forgings represented by such specimen shall be retempered or requenched and retempered.

(b) If the results of the physical tests of any test lot do not conform to the requirements specified, the manufacturer may retemper or requench and

retemper such lot, but not more than three additional times, unless authorized by the purchaser, and retests shall be made as specified in Section 14.

IV. Workmanship and Finish.

16. **WORKMANSHIP.**—The forgings shall conform to the sizes and shapes specified by the purchaser. Axles, shafts and similar forgings, unless otherwise specified, shall be rough turned with an allowance of ⅛ in. on the surface for finishing, except on the collars of axles or other forgings, which shall be left rough forged. In centering 60 deg. centers with clearance drilled for points shall be used.

17. **FINISH.**—The forgings shall be free from injurious defects and shall have a workmanlike finish.

V. Marking.

18. **MARKING.**—Identification marks shall be legibly stamped on each forging and on each test specimen. The purchaser shall indicate the location of such identification marks.

VI. Inspection and Rejection.

19. **INSPECTION.**—(a) The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the forgings ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the forgings are being furnished in accordance with these specifications. Tests and inspection at the place of manufacture shall be made prior to shipment.

(b) The purchaser may make the tests to govern the acceptance or rejection of the forgings in his own laboratory or elsewhere. Such tests, however, shall be made at the expense of the purchaser.

(c) Tests and inspection shall be so conducted as not to interfere with the operation of the works.

20. **REJECTION.**—(a) Unless otherwise specified, any rejection based on tests made in accordance with Section 19 (b) shall be reported within five working days from the receipt of the samples.

(b) Forgings which show injurious defects while being finished by the purchaser will be rejected, and the manufacturer shall be notified.

21. **REHEARING.**—Samples tested in accordance with Section 19 (b) which represent rejected forgings shall be preserved for two weeks from the date of test report. In case of dissatisfaction with results of tests, the manufacturer may make claim for a rehearing within that time.

22. **FREIGHT CHARGES.**—All rejected forgings will be returned to the manufacturer, who shall pay freight charges both ways.

EXHIBIT "B."

STANDARD SPECIFICATIONS FOR QUENCHED AND TEMPERED ALLOY STEEL FORGINGS.

1. **BASIS OF PURCHASE.**—(a) These specifications cover the various classes of chrome-nickel and chrome-vanadium alloy steel forgings now commonly used in locomotive construction.

(b) The purposes for which these classes are frequently used are as follows:

CLASS A.—Forgings for main and side rods, straps and piston rods, and all other forgings which are to be machined with milling cutters or complicated forming tools, or when there is an abrupt change in section.

CLASS B.—Forgings for driving and trailer axles, crank pins, plain piston rods, cross-head pins and other forgings not requiring the use of milling cutters or complicated forming tools.

I. Manufacture.

2. **PROCESS.**—The steel may be made by the open-hearth or other process approved by the purchaser.

3. **DISCARD.**—A sufficient discard shall be made from each ingot to secure freedom from injurious piping and undue segregation.

4. **PROLONGATION FOR TEST.**—For test purposes a prolongation shall be left on each forging, unless otherwise specified by the purchaser.

5. **BORING.**—(a) All forgings over 7 in. in diameter shall be bored, unless otherwise specified by the purchaser. The boring shall be done before quenching.

(b) If boring is specified, the diameter of the hole shall be at least 20 per cent of the maximum outside diameter or thickness of the forging, exclusive of collars and flanges.

6. **HEAT TREATMENT.**—For quenching and tempering, the forgings shall be allowed to become cold after forging. They shall then be uniformly reheated to the proper temperature to refine the grain (a group thus reheated being known as a quenching charge) and quenched in some medium under substantially uniform conditions for each quenching charge. Finally they shall be uniformly reheated to the proper temperature for tempering or "drawing back" (a group thus reheated being known as a tempering charge) and allowed to cool uniformly.

II. Chemical Properties and Tests.

7. **CHEMICAL COMPOSITION.**—The steel shall conform to the following requirements as to chemical composition.

	Chrome Nickel	Chrome Vanadium
Carbon	0.28—0.42 per cent	0.28—0.42 per cent
Manganese	0.40—0.70 "	0.40—0.70 "
Silicon	0.10—0.30 "	....
Phosphorus, not over	0.05 "	0.05 per cent
Sulphur, not over	0.05 "	0.05 "
Chromium	0.60—1.00 "	0.75—1.25 "
Nickel	1.00—1.50 "	....
Vanadium, not under	....	0.15 per cent

8. **LADLE ANALYSIS.**—An analysis shall be made by the manufacturer from a test ingot taken during the pouring of each melt, a copy of which shall be given the purchaser or his representative. This analysis shall conform to the requirements specified in Section 7.

9. **CHECK ANALYSIS.**—(a) An analysis may be made by the purchaser from a forging representing each melt, which shall conform to the requirements specified in Section 7. Drillings for analysis may be taken from a forging, or from a full-sized prolongation of the same, at any point midway between the center and surface of solid forgings, and at any point midway between the inner and outer surfaces of the wall of the bored forgings, or turnings may be taken from a test specimen.

(b) In addition to the complete analysis a phosphorus determination may be made by the purchaser from each tension test specimen, and this determination shall conform to the requirements for phosphorus specified in Section 7.

III. Physical Properties and Tests.

10. **TENSION TESTS.**—(a) The forgings shall conform to the requirements as to tensile properties specified in Table 1.

Table No. 1.

For forgings whose maximum diameter or thickness is not over 10 in. when solid.

CLASS A.

	Tens. str. lb. per sq. in.	Elastic limit minimum lb. per sq. in.	Elongation in 2 in. minimum per cent	Reduction of area minimum per cent
Main and side rods, straps, piston rods...	90 000 to 110 000	65 000	20	50

CLASS B.

	Tens. str. lb. per sq. in.	Elastic limit minimum lb. per sq. in.	Elongation in 2 in. minimum per cent.	Reduction of area minimum per cent
Up to 7 in. diameter or thickness when solid, or 3½-in. max. wall..	100 000 to 120 000	75 000	20	50
7 in. to 10 in. diam. or thickness when solid, or 5-in. max. wall....	100,000 to 120 000	75 000	18	45

(b) The classification by size of the forgings shall be determined by the specified diameter or thickness which governs the size of the prolongation from which the test specimen is taken.

(c) Elastic limit shall be determined by means of an extensometer of a type the equal of the "Berry" strain gage.

(d) Test of forgings shall be made only after final treatment.

(e) The speed of the test machine shall not exceed ⅛ in. per minute until the elastic limit has been reached.

11. **BEND TESTS.**—If specified by the purchaser bend tests shall be made as follows:

(a) For forgings up to 7 in. in diameter or thickness when solid, or 3½-in. maximum wall, the test specimen shall bend cold through 180 deg. on a 1-in. flat mandrel having a rounded edge of ½ in. radius without cracking on the outside of the bent portion.

(b) For forgings 7 in. to 10 in. in diameter or thickness when solid, or 5-in. maximum wall, the test specimen shall bend cold through 180 deg. around a 1½-in. flat mandrel having a rounded edge of ¾ in. radius without cracking on the outside of the bent portion.

12. **PROOF TEST.**—(a) Unless otherwise specified by the purchaser, all forgings shall be subjected to an impact proof test. The details of this test shall be agreed upon by the manufacturer and the purchaser.

(b) A recommended test for axles, shafts and similar forgings is as follows: Place the forging upon supports 3 ft. apart mounted on an M. C. B. drop test machine. The forging should then be struck two blows by a tup weighing either 1640 or 2240 lb. falling from heights proportioned according to the following formula and tabulation. Between the first and second blows the forging shall be turned 90 deg.

Height of drop in feet $= 0.01\ D^2$ for 1640-lb. tup.

Height of drop in feet $= 0.0073\ D^2$ for 2240-lb. tup.

NOTE.—D = diameter of shaft or thickness of forging at center.

TABLE No. 2.

Diameter of Shaft at center, inches	Height of drop in feet	
	1640-lb. tup	2240-lb. tup.
5	1 ft. 3 in	0 ft. 11 in.
5½	1 ft. 8 in	1 ft. 3 in.
6	2 ft. 2 in	1 ft. 7 in.
6½	2 ft. 9 in	2 ft. 0 in.
7	3 ft. 5 in	2 ft. 6 in.
7½	4 ft. 3 in	3 ft. 1 in.
8	5 ft. 1 in	3 ft. 9 in.
8½	6 ft. 2 in	4 ft. 6 in.
9	7 ft. 3 in	5 ft. 4 in.
9½	8 ft. 7 in	6 ft. 3 in.
10	10 ft. 0 in	7 ft. 4 in.
10½	11 ft. 7 in	8 ft. 5 in.
11	13 ft. 4 in	9 ft. 9 in.
11½	15 ft. 3 in	11 ft. 3 in.
12	17 ft. 3 in	12 ft. 7 in.
12½	19 ft. 5 in	14 ft. 3 in.
13	22 ft. 0 in	16 ft. 0 in.
13½	24 ft. 7 in	18 ft. 0 in.
14	27 ft. 5 in	20 ft. 0 in.
14½	30 ft. 6 in	22 ft. 3 in.
15	33 ft. 9 in	24 ft. 8 in.

NOTE.—The above heights are to the nearest inch.

13. **TEST SPECIMEN.**—(a) Tension and bend test specimens shall be taken from a full size prolongation of any forging. For forgings with large ends or collars, the prolongation may be of the same cross section as that of the forging back of the large end or collar. Specimens may be taken from the forging itself with a hollow drill, if approved by the purchaser.

(b) The axis of the specimen shall be located at any point midway between the center and surface of solid forgings, and at any point midway between the inner and outer surfaces of the wall of the bored forgings, and shall be parallel to the axis of the forging in the direction in which the metal is most drawn out.

(c) Tension test specimens shall be of the form and dimensions shown in Fig. 1.

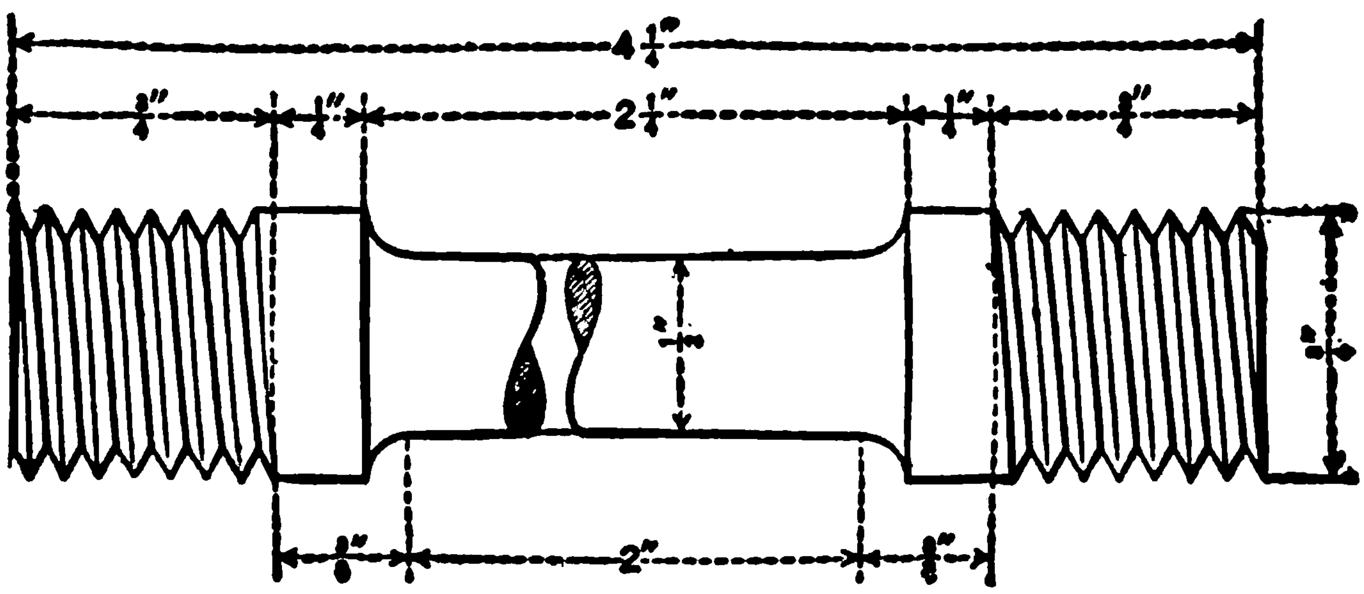


FIG. 1.

(d) Bend test specimens shall be ½ in. square in section with corners rounded to a radius not over $\frac{1}{16}$ in. and need not exceed 6 in. in length.

14. **NUMBER OF TESTS.**—(a) One tension, and if specified by the purchaser, one bend test shall be made from each tempering charge. If more than one quenching charge is represented in a tempering charge, one tension and, if specified, one bend test shall be made from each quenching charge. If more than one melt is represented in a quenching charge, one tension and, if specified, one bend test shall be made from each melt.

(b) If more than one class of forgings by size is represented in any lot, one tension and, if specified, one bend test from a forging of each class by size shall be made as specified in Sections 10, 11 and 13.

(c) If any test specimen shows defective machining or develops flaws, it may be discarded and another specimen substituted.

(d) If the percentage of elongation of any tension test specimen is less than that specified in Section 10 (a) and any part of the fracture is more than ¾ in. from the center of the gage length, as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed.

15. **RETESTS.**—(a) If the fracture of any tension test specimen shows over 15 per cent crystalline, a second test shall be made. If the fracture of the second specimen shows over 15 per cent crystalline, the forgings represented by such specimen shall be retempered or requenched and retempered.

(b) If the results of the physical tests of any lot do not conform to the requirements specified, the manufacturer may retemper or requench and retemper such lot, but not more than three additional times, unless authorized by the purchaser, and retests shall be made as specified in Section 14.

IV. Workmanship and Finish.

16. **WORKMANSHIP.**—The forgings shall conform to the sizes and shapes specified, by the purchaser. Axles, shafts and similar forgings, unless otherwise specified, shall be rough turned with an allowance of ⅛ in. on the surface for finishing, except on the collars of axles or other forgings, which shall be left rough forged. In centering 60 deg. centers with clearance drilled for points shall be used.

17. **FINISH.**—The forgings shall be free from injurious defects and shall have a workmanlike finish.

V. Marking.

18. **MARKING.**—Identification marks shall be legibly stamped on each forging and on each test specimen. The purchaser shall indicate the location of such identification marks.

VI. Inspection and Rejection.

19. **INSPECTION.**—(a) The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the forgings ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the forgings are being furnished in accordance with these specifications. Tests and inspections at the place of manufacture shall be made prior to shipment.

(b) The purchaser may make the tests to govern the acceptance or rejection of the forgings in his own laboratory or elsewhere. Such tests, however, shall be made at the expense of the purchaser.

(c) Tests and inspection shall be so conducted as not to interfere with the operation of the works.

20. **REJECTION.**—(a) Unless otherwise specified, any rejection based on tests made in accordance with Section 19 (b) shall be reported within five working days from the receipt of the samples.

(b) Forgings which show injurious defects while being finished by the purchaser will be rejected, and the manufacturer shall be notified.

21. **REHEARING.**—Samples tested in accordance with Section 19 (b) which represent rejected forgings shall be preserved for two weeks from the date of test report. In case of dissatisfaction with results of tests, the manufacturer may make claim for a rehearing within that time.

22. **FREIGHT CHARGES.**—All rejected forgings will be returned to the manufacturer, who shall pay freight charges both ways.

The Chairman: What action will you take upon this report?

Mr. Young: I move you, Mr. Chairman, that the recommendations of the committee contained on page 2 be submitted to letter ballot as recommended practice.

Motion seconded and carried.

Mr. A. R. Ayers (N. Y. C. R. R.): On page 8, under Class A, the committee includes piston rods which are subject to requirements of ten thousand pounds per square inch less than axles, crank pins, etc. My recollection is that that was worded that way in the original alloy-steel specifications, and was later corrected, so as to put piston rods in Class B, to get the benefit of the heavier requirements. It is not evident why piston rods should not be subject to just as good treatment as axles, and I ask Mr. Young if there would be any objection to putting piston rods on their Class B, with axles, as shown on page 8?

Mr. Young: Class B says "and other forgings." It was the thought of the committee, I believe, at the time this was discussed, that it might be well to keep piston rods, especially those which are hollow-bored and forged, under Class A, and, if desired, they could be included as "other forgings" under Class B. I see no objection in specifically mentioning piston rods in both classes. The classes must take care of themselves by the expression of what they are supposed to cover.

Mr. Ayers: There did not seem to be any logical reason for taking the piston rods, a round shaft of small diameter, and putting it in with complicated forgings, and leaving all kinds of axles in Class B.

Mr. Young: I can see no objection to including it in both classes, but I do not see why there should be any objection to having hollow-bored piston rods, especially where there is a change in section due to crosshead fit, included in Class A. I do not know whether it would be proper to put such a piston rod in both classes. "Other forgings" expresses it, but I see no objection to mentioning it in Class B.

The Chairman: If the committee is prepared to make that

change, it would be well to have it plainly stated, so that there would be no misunderstanding in the letter ballot.

MR. YOUNG: The committee thought that "other forgings" covered it. If it would make it clearer, it would be well to include piston rods in Class B.

THE CHAIRMAN: The Chair does not seem to be quite clear on this. It was thought that these specifications would be quite definite. If you put one article in both classes, may nót that remove some of the definiteness in the specifications? Have you anything further, Mr. Young?

MR. YOUNG: I think not.

THE CHAIRMAN: Then the action taken by the convention will be followed.

The next business is the report of the Committee on Boiler Washing, which will be presented by Mr. John Purcell, Asst. to Vice-President, A. T. & S. F. Ry., chairman of the committee.

Mr. Purcell presented the report, as follows:

REPORT OF COMMITTEE ON BOILER WASHING.

To the Members:

Your Committee on Boiler Washing, in its endeavor to ascertain the general practice of washing locomotive boilers, sent out the following letter and questions:

"CHICAGO, ILL., January 1, 1915.

Mr......................, *Superintendent Motive Power*,............

..............:

MY DEAR SIR,—

As Chairman of the Committee on Boiler Washing of the Railway Master Mechanics' Association, I am attaching herewith a list of questions which I would appreciate very much if you would have filled out and returned to me, at 1018 Railway Exchange building, Chicago, on or before January 31, 1915.

The committee is anxious to get the general information from all the principal railroads in the country, and we will greatly appreciate your co-operation in making this report a thoroughly representative one, and oblige,

Yours very truly,
(Signed) JOHN PURCELL,
Chairman.

JOHN PURCELL, Chairman,
W. H. FETNER,
J. C. LITTLE,
W. P. CARROLL,
G. W. RINK,
E. S. FITZSIMMONS,
G. E. SISCO,
Committee.

1. Name of road .... No. of engines ....

2. How many miles do you make between wash-outs? Freight........ Passenger ....

3. How many miles between water changes? Freight .... Passenger ....

4. How many miles between blowouts? Freight .... Passenger ....

A blowout refers to blowing out at terminals when large quantities of water are blown out, which is often done without knocking fire.

5. How many wash-out holes do you have in your modern heavy power boilers? ....

6. What is the average cost of boiler washing per engine? Hot and cold water systems ....

7. Give boiler washing pressure at pump and nozzle ....

8. Do you use hot water boiler washing system? ....

9. Do you find the hot water plant reduces amount of water used, and if so, how much per engine? ....

10. What is the saving in time? ....

11. What is the saving in fuel? ....

12. Do you notice any improvement in performance of fire-box stay-bolts or flues since hot water washout plant was installed? ....

13. Do you treat water in road side tanks, if so to what extent and system used? ....

14. Do you treat water in engine tanks? What chemicals do you use? ....

15. How do you treat water to prevent incrustation and with what? ....

16. How do you treat water to prevent foaming, and with what success?
. . . .

17. How do you treat water to prevent corrosion and pitting, and with what success? . . . .

18. Do you find that water treatment increases repairs to valve and piston packing or breakage of motion parts? . . . .

19. Do you find your system of water treatment increases the mileage between flue settings and boiler repairs? If so, to what extent? . . . .
. . . .

20. What experience have you had with mechanical water purifiers?
. . . .

Please furnish copy of your rules for washing boilers. The committee will appreciate your co-operation and earnestly requests that your answers to the above be returned not later than January 31, 1915.

____

(Signature of Officer.)

____

(Title.)

To be filled out complete and returned to
John Purcell, 1018 Railway Exchange, Chicago.

From the answers received we have summarized as follows:

Number of letters sent out	118
Number of replies received	93
Locomotives represented by replies	51 294

2. Miles Made between Wash-outs.—9760 engines make less than 500 miles. 11,283 engines make over 500 and less than 1000 miles. 8312 engines make over 1000 and less than 1500 miles. 20,472 engines make over 1500 miles. 2467 not replying or unable to furnish information. The passenger locomotives make 30 per cent greater mileage between wash-outs than freight engines.

3. Water Changes.—Only about five per cent of the roads in the country practice changing water in the boilers.

4. Blowing Out at Terminals.—About fifteen per cent practiced some regular system of blowing boilers at terminals. About thirty five per cent of engines are blown out regularly and systematically while on the road to remove mud or sludge that may have accumulated in boiler, and to prevent foaming.

5. Wash-out Holes in Boilers.—The maximum number of wash-out plugs reported in a boiler was 52, with a minimum of ten, or an average on all modern power of 32.

6. Cost of Washing Boilers.—The answers to this question show a wide variance as to cost, some reporting as low as 10 cents, while others were as high as $5.50. It is evident this question was not thoroughly understood,

as some roads only reported the cost of water. From the information gathered from the reports it cost about thirty-five per cent less to wash with hot water than it does with cold water.

7. Boiler Washing Pressure.—The average boiler washing pressure at the pump or line was 96 lb. and about seventy-two pounds at the nozzle.

8. Hot Water System for Washing Boilers.—Hot water systems were reported as being used on 54 roads, 13 being the maximum number reported on any one road. Some roads only reported using same at one or two roundhouses. Some report using injector to heat washing and filling water.

9. Reduction of Water on Account of Hot Water Plants.—The use of hot water for boiler washing plants shows an average reduction in the amount of water used of 3427 gal. or 36 per cent, some roads reporting as much as 9000 gal.

10. Reduction in Amount of Time on Account of Hot Wate Plants.—A reduction in time of 1 hr. and 54 min., or 42 per cent.

11. Saving of Fuel on Account of Hot Water Plants.—A saving in fuel of 897 lb., or 36 per cent.

12. Improvement in Performance of Fire-box Sheets, Stays, etc., on Account of Hot Water Plants.—All roads except one report a great reduction in boiler troubles, especially as to cracked sheets, leaky stays, etc., or an average reduction in these troubles of 34 per cent.

13. Water-treating Plants.—Thirty-one roads report using water-softening plants at wayside tanks.

14. Treating Water in Engine Tanks.—Forty-five roads report using chemicals in engine tenders, 19 using soda ash and 26 boiler compound.

15. Treatment to Prevent Incrustation.—Seventy-six roads report using boiler compound, soda ash and other chemicals, to prevent incrustation.

16. Treatment to Prevent Foaming.—Twenty-nine roads report using boiler compound or other chemicals to prevent foaming.

17. Treatment to Prevent Corrosion and Pitting.—Very few roads specifically treat water to prevent corrosion, but water treatment as explained in answers to Questions 13, 14 and 15, often prevents corrosion of sheets, flues, etc.

18. Increased Repairs to Packing, Cylinders, etc., Due to Water Treatment.—Seven roads report water treatment increasing repairs to valves and packing, due principally to boiler foaming. Others report no increase in repairs.

19. Increased Mileage Due to Water Treatment.—All roads using water-softening plants report great increase in mileage between flue setting and boiler repairs, some roads reporting as high as 300 per cent. An average increase in mileage of over 100 per cent is given.

20. EXPERIENCE IN HANDLING MECHANICAL WATER PURIFIERS.—None of the roads report using mechanical water purifiers. Some report as having experimented in the past, but not using same at the present time.

RULES.—Sixteen of the roads report having regular rules governing the washing of boilers, and the majority report that they comply simply with the Interstate Commerce Commission's instructions as to washing boilers.

In further explanation of the above answers, washing boilers depends entirely on the water conditions. A number of roads report running 30 days, the full limit allowed by the Interstate Commerce Commission, between washings of boilers. Other roads in the so-called bad water section report the necessity of washing out every 100 miles.

In explanation of answer to Question No. 4 in reference to blowing out, while some roads have regular systematic methods of blowing out boilers at terminals, the majority seem to leave it entirely with the engine crew. The practice of blowing out while on the road, especially where water is treated, and the strong tendency of treated water to foam, makes it imperative for the engine crew to use blow-off cocks quite freely between terminals. It has been demonstrated on two or three roads using water which foams badly that with the intelligent use of anti-foaming boiler compound and a liberal use of blow-off cocks, a locomotive could be run 2000 miles or more without foaming trouble. Better results are obtained if boiler is blown out, while not using steam, or after engine has been standing a while. Some roads provide boxes or receptacles at terminals or coal and water stations, into which the water is blown, this to prevent damage to buildings, cars, etc.

As to Question No. 6, the cost of washing boilers, as stated, this question was evidently misunderstood, as the cost of washing boilers should include labor, cost of water and the cost of wash-out hose, and the maintenance of nozzles, scrapers, etc. With the large modern boilers where engines are thoroughly washed, it is evident from this report that this can not be thoroughly done for less than $3.50, where cold water is used, both for cooling down and washing out, and where scraper is used and loose scale removed.

As to Question No. 8, the use of the hot water system is rapidly increasing. The reports do not state what kind of systems are used, whether the water or steam or the heat of both are conserved for heating cold water for washing purposes, or whether the same water is used for washing. A number of our western roads where water is expensive, or where it costs as high as ten to fifteen cents per thousand gallons, the saving of water is quite an item, and the practice of not only conserving the heat in boilers being blown out, but the water in the boilers is saved for washing purposes. The hot water system is very desirable where engines are pooled and the rapid turning of power is desired.

Question 13. Water treating or softening plants are more numerous on the western roads in the so-called bad water country than any other section. The number of treating plants on some roads varies as to conditions of the water and to the importance of the divisions, one road reporting

115 water-softening plants, and some roads reporting one or two. From the expressions of the roads treating water, better results are accomplished in heating water in wayside tanks, than in placing chemicals directly into engine-tender tanks.

Question 14. Treatment of water in engine tanks.—This practice is more prevalent on divisions where they have one or two bad water stations, the other water on the division being good. All the roads report a great improvement in boiler maintenance where water softening is practiced, either in wayside tanks or where chemicals are used in the engine tenders. Practically all the treatment of water is to prevent incrustation. Very little attention apparently has been given to corrosion or pitting of boiler sheets or flues, although indirectly the treatment of water for removing incrustants has also removed a great deal of the corrosive or pitting elements.

Question 16. Foaming.—The majority of the roads using treated water report water foaming a great deal more after treatment than before. This is quite common with all treated water and the roads have resorted to the use of anti-foaming compounds and a liberal use of the blow-off cocks, to prevent this. A slight increase in the wear of packing and lubricator oil is reported on some roads where foaming conditions are bad. But the great majority report no appreciable increase.

Boilers are washed for two general reasons:

First: To remove the accumulation of mud or scale and prevent the overheating of fire-box plates and flues.

Second: To remove the slime and sludge or other matters which, if allowed to remain, will cause foaming and also to wash from all parts any injurious concentrates that may have a tendency to cause corrosion.

The frequency of wash-outs and the number and location of wash-out holes largely depend upon the construction of the boiler and the conditions under which it is being operated, and the performance of the boiler during operation, if it is good, indicates that the wash-out requirements are being met with, while a poor performance indicates the opposite.

Owing to the great difference in conditions under which locomotives are operated it is felt that the subject can be successfully treated only in a general way, and the following method of washing boilers is given at this time as being a good general practice:

Frequency of Washing.

1. All locomotives in service must have boilers washed at least once every thirty days, or more frequently if conditions require.

Cooling Boilers.

2. Boilers should be thoroughly cooled before being washed, excepting at points where improved hot water wash-out systems are installed. When boilers are cooled in the natural way without the use of water, the steam should be blown off, but the water must be retained above the top of crown sheet and boiler allowed to stand until the temperature of the steel in fire box is

reduced to about ninety degrees, or so that it feels cool to the hand; then the water is drawn off and the boiler washed. When the engine can not be spared from service sufficiently long for it to be cooled in this manner before washing, proceed as follows:

Use of Injector Cooling Boilers.

3. When there is sufficient steam pressure, start the injector and fill the boiler with water until the steam pressure will no longer work the injector. Then connect water-pressure hose to feed pipe between engine and tender and fill the boiler full, allowing the remaining steam pressure to blow through syphon cock or some other outlet at top of the boiler. Open blow-off cock and allow water to escape, but not faster than it is forced in through the check, so as to keep the boiler completely filled until the temperature of the steel in the fire box is reduced to about ninety degrees, then remove all plugs and allow boiler to empty itself.

How to Wash a Boiler.

4. Remove all wash-out plugs. Begin washing through holes on side of boiler opposite front end of crown sheet. Wash top of crown sheet at front end, using Nozzle No. 1 or 2. Then use Nozzles 3 and 4 to wash between rows of crown bars and bolts at right angles to nozzle, directing the stream toward the back end of crown sheet. After washing through holes near front end of crown sheet, use holes in their respective order toward the back of the crown sheet. The object of this method is to work the mud and scale from the crown sheet toward the side and back legs of the boiler and prevent depositing it on the back ends of the flues.

Washing Crown Sheet.

5. Next wash crown sheet from boiler head, using Nozzles 1 and 3 or 6. When Nos. 3 or 6 are employed, the swivel connection with hose should be used and nozzle should be inserted to the front end of crown sheet and slowly drawn back and revolved at the same time, so as to wash top of boiler and all radial stays or bolts as well as the crown sheet.

Washing Flues.

6. Wash back end of flues through holes in connection sheet, using Nozzles Nos. 1, 5 and 6, and revolve same by means of swivel connection when the curved nozzles are used. The same nozzles are to be used and the same system followed when washing any part of the flues or feed-water heater flues.

Washing Back Head Water Spaces.

7. Wash the water space between back head and fire-box door sheet through the holes in back head with Nozzle No. 6, being careful to remove all scale and mud above and below fire-door hole.

Washing Arch Tubes.

8. Arch tubes must be washed and scraped clean with scrapers or pneumatic cleaners every time the boiler is washed. If scale is allowed to form in

arch tubes the metal becomes overheated and bulges are formed, and, if allowed to remain, tube warps out of line with holes, strains are set up and cracks develop, and the tube is very dangerous and liable to pull out or explode. Therefore a locomotive should not be allowed to leave a terminal with dirty arch tubes, and all concerned are instructed to strictly comply with the rule.

NOTE.—The condition of an arch tube as to scale on the water side can readily be determined by the presence of clinker adhering on the fire side. If an arch tube is clean on the water side it will be clean and smooth on the fire side. The condition of fire-box sheets can usually be determined by similar evidence. It may be laid down as a general rule that clean fire boxes on the water side are clean and smooth on the fire side. Any clinker adhering or sand paper roughness on the fire side indicates scale formation opposite.

WASHING SIDE-SHEET WATER SPACES.

9. Now return to holes on side of boiler opposite crown sheet, using Nozzles 5 and 6, and revolve same so as to thoroughly wash down side sheets and staybolts, making sure that all spaces on side of fire box are clear of mud and scale. Then wash through holes near check valves near front end of boiler, using Nozzles 1 and 5 or 6, with swivel connection.

WASHING BARREL OF BOILER.

10. Then wash through hole in bottom of barrel of boiler near the rear end, and wash toward the front end. If engine has no mud drum, wash toward the throat sheet with Nozzles 5 or 6. Then use straight nozzle directly against the flues, reaching as great space as possible in all directions. Then use the bent nozzle through the front hole in bottom of barrel, and also the straight nozzle in same manner as above, until certain that the flues and spaces between the flues and barrel are as clean as it is possible to make them.

WASHING MUD RING.

11. Then use Nozzles Nos. 5 and 6 in the side and corner holes of water legs, revolving same thoroughly to clean the side sheets, and finally clean off all scale and mud from the mud ring by means of straight nozzles in the corner holes.

INSPECTION AFTER WASHING.

12. It must not be assumed that because clear water runs from the holes that the boiler is cleaned, but all spaces must be examined carefully with rod and light, and, if necessary, use a pick, steel scraper or other tools, to remove accumulated scale.

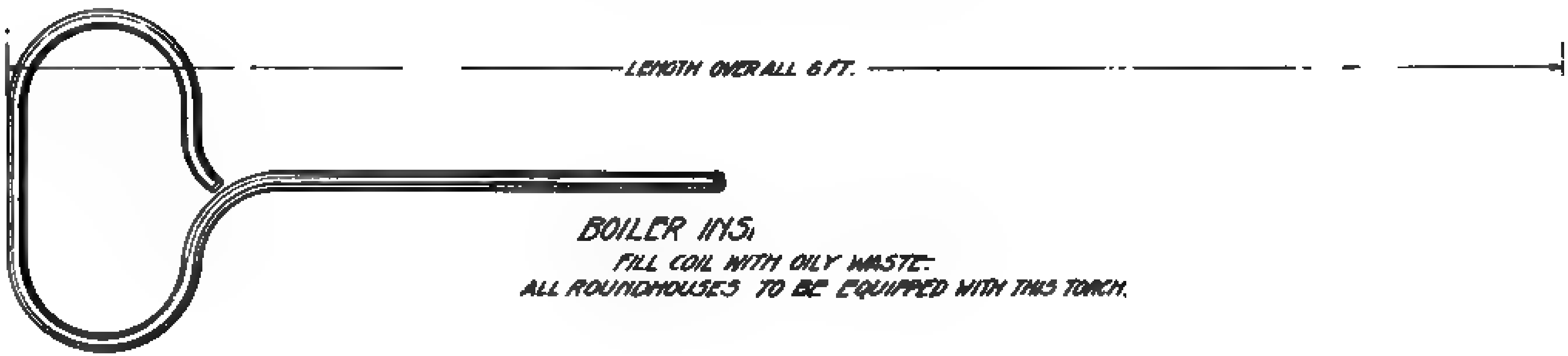
FILLING BOILERS.

13. When cooling and filling boilers, they must be filled through the injector check. The injector steam pipe valve at the fountain must be closed. Filling up boilers through blow-off cocks will not be permitted except at hot water boiler washing plants and when hot water is being used.

On pages 9 and 10 are shown boiler-washing nozzles and inspection torches.

4

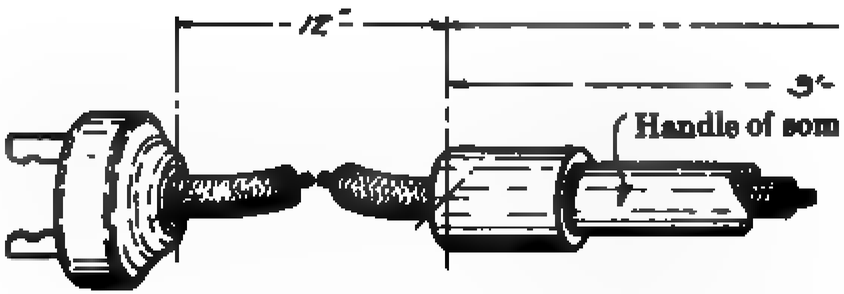
ALL ROUNDHOUSES TO ... AS FOLLOWS; ONE 5 FT. LONG AND ONE 11 FT. LONG.



BOILER INS.

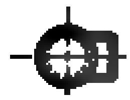
FILL COIL WITH OILY WASTE.

ALL ROUNDHOUSES TO BE EQUIPPED WITH THIS TORCH.



BOILER INS

ALL ELECTRIC LIGHTED ROUNDHOUSES TO BE EQU
TOPEKA, NEWTON, RATON AND NEEDLES SHOULD SPECIFY 60 WATTS, 230 VOLTS; SAN BERNARDINO 60 WATTS, 120 VOLTS; ALL OTHER POINTS 60 WATTS, 110 VOLTS.



WASHOUT NOZZLES.

We believe very strongly in thoroughly washing out boilers, and in order to be sure that good washing is being done and that the boiler is thoroughly inspected after it is washed, the roundhouse boiler foreman or boiler inspector should make the inspection.

Experience shows that wash-out nozzles should be smooth and constructed so as to throw a solid stream out of a ⅝-in. hole with 100 lb. pressure back of it for a distance of ten or twelve feet, which gives a very effective washing force. The aim is to have 100 lb. pressure at the nozzle, which can usually be had by having 125 lb. at the pump; this varies somewhat according to pipe lines.

Hot Water Boiler Washing Plants.

The Santa Fe System has been able to give us some accurate and reliable figures on the cost of washing boilers with both hot and cold water, and we quote as follows from the complete report furnished your committee by this road:

"We use both the hot and cold water boiler washing systems, having one Gordon, three National and seven Santa Fe hot water wash-out plants, which are located at some of our principal wash-out plants. Our tests show that the hot water system is superior to the cold in quicker handling of power, and using less water and fuel.

Our figures show, with the cold water wash-out system (not including overhead charges), a cost of $4.42 to handle a modern locomotive boiler; this includes cooling from 100 lb. steam pressure, emptying, washing, filling, firing up and raising steam pressure to 100 lb., also cost of water and fuel, and requires not less than five hours' time for the operation, while with the hot water system a boiler can be emptied, washed, filled, fired up and steam raised to 100 lb. pressure for $3.01, including cost of water and fuel. A saving of $1.41, and a reduction in time of about one and one-half hours for each engine.

The operation of changing water in a boiler we find, with the cold water plants, costs $3.54, with the hot water plants $2.13, a water change being only 88 cents cheaper than a wash-out with either system; this is on account of not removing wash-out plugs and washing boiler, also cost of washing water.

The attached is a detailed statement showing our conclusions as to these costs. This is from a number of tests and the figures shown are such as will be approximated by the average efficient boiler-washing gang, with good boiler-washing facilities.

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COST OF BOILER WASHING, COLD WATER WASHING SYSTEM, IS ITEMIZED AS FOLLOWS:

A modern boiler, 100 lb. steam; 4 in. of water in glass.

Cooling to 90 °F., cooling water 57 °F., 9000 gal. at 4 cents per 1000 gal	$0.36
Time cooling and draining boiler 2 hr. 30 min. at 20 cts. per hr., one man	.50
Removing and replacing plugs, two men, 30 min., 40 cents per hr	.20
Washing boiler, two men, 1 hr. at 40 cents per hr	.40
Water used washing boiler, 3000 gal. at 4 cents per M. gal	.12
Water used filling boiler, 4000 gal. at 4 cents per M. gal	.16
Time filling boiler, 45 min., 1 man at 20 cents per hr	.15
Laying fire bed, 1000 lb. coal, 10 cents per 100 lb	1.00
Additional fuel to raise steam to 100 lb. boiler pressure, 1100 lb	1.10
Time of fire builder, 45 min	.15
Add 20 per cent to time of men for changing tools from engine to engine	.28
Total	$4.42

COST OF BOILER WASHING, HOT WATER WASH-OUT SYSTEM.

A modern boiler, 100 lb. steam; 4 in. of water in glass.

Blowing steam and water out of boiler, one man, 1 hr	$0.20
Removing and replacing plugs, two men 30 min., 40 cents per hr	.20
Washing boiler, two men, 1 hr. at 40 cents per hr	.40
Water used washing boiler, 3000 gal., 4 cents per M. gal	.12
Water used filling boiler, 4000 gal., 4 cents per M. gal	.16
Time filling boiler, 45 min., one man at 20 cents per hr	.15
Laying fire bed, 1000 lb. coal, 10 cents per hundred	1.00
Additional fuel to raise steam to 100 lb. boiler pressure, 500 lb. at 10 cents per 100 lb	.50
Time of fire builder, 30 min., at 20 cents per hr	.10
Add 20 per cent to time of men for changing tools from engine to engine.	.18
Total	$3.01

The cost for a water change is 88 cents less than cost of a wash-out, either system as follows:

Less 3000 gal. water for washing	$0.12
Less removing and replacing wash-out plugs and washing boiler	.62
Less removing and changing tools, 20 per cent	.14
Total	$0.88

Therefore water changing at a cold water plant costs	$3.54
Therefore water changing at a hot water plant costs	2.13

It might be well at this time to observe that the saving in water and fuel of the hot water over the cold water system depends upon how well the hot water plant is operated. It is our observation that a well-kept hot water boiler washing plant is a certain economy, while a poorly operated and maintained plant may be conducted at a loss.

The temperature of the boiler washing water should be maintained not less than 130 deg. and the filling water as much hotter as it can be obtained without the use of live steam, and in order to insure an ample supply of washing and filling water at high temperatures, reservoirs of ample capacity should be provided to conserve heat which may be collected from various sources, other than that blown out by locomotives and which can profitably be applied in heating the washing or filling water for locomotive boilers.

The Central of Georgia reports making some tests on cost saving and time saving on boiler washing with hot water wash-out systems as compared with cold water. These tests were followed up accurately by testing engineer, with watch, actual weights on fuel, and actual consumption of water by use of meter.

The saving in boiler maintenance and repiars, as well as flue and fire-box failures on line of road, shows a decided improvement when engines are washed with mechanical hot water system as compared with cold water system. For instance, on this road, with average water conditions, since installing hot water washing outfit we have practically doubled our life on flues. The life of fire boxes, staybolts and boiler sheets shows a material improvement. We have practically eliminated the item of failures on line of road account of leaky flues and fire boxes, and, last but not least, we have doubled the mileage of engines between wash-outs.

Under these circumstances we are saving in boiler and flue repairs, as a very conservative figure, $200 per locomotive per year, with the hot water system as compared with cold water. In the bad water districts these figures would show considerable increase.

Mechanical officers know the above to be facts, but we should go further and furnish them with figures on the average cost of a hot water outfit for the average small enginehouse, outfit being piped to from three to eight pits. They can take their boiler wash records then and submit cost statements to their executive officers, showing what the actual saving per year on the investment would be. For instance, with the outfit we have at our Macon enginehouse piped to 17 pits, we would only have to wash out average of two engines per day to show an actual money saving on investment of 5.7 per cent.

An outfit for average small enginehouse could be installed for $7500.

Take the average small enginehouse handling 25 locomotives, where the freight engines are pooled, the actual amount of time saved in holding engines for boiler washing and repairs would enable them to get more mileage out of each engine, and the combined mileage would enable them to handle the same amount of business with one or two less engines than with the cold water system of washing.

Taking into consideration the actual cost saving in washing, the time saving enabling each engine to make greater average mileage, and the decreased cost of boiler maintenance, mechanical officers have very good information for recommending to executive officers the installation of hot water boiler wash outfits at the average size enginehouse.

The Central Railroad of New Jersey reports the installation of a hot water wash-out and filling plant about a year ago, of the following description and test results:

There is in operation at the Communipaw roundhouse, of the Central Railroad of New Jersey, at Jersey City, a Winter's Boiler Wash-out Plant. As this is considered the latest in boiler washing systems, it would appear desirable to include same in the report.

The plant consists of two standard 3-in. cypress tanks, one submerged within the other. The outside tank forms the hot well in which the locomotives are blown off; the inside tank contains the water for refilling.

The following data indicate result of tests made at this plant from September 1, 1914, to November 30, 1914:

Total Number of Engines put through Plant for any Purpose.	Sept. 1 to 30. 202	Oct. 1 to 31. 228	Nov. 1 to 30. 226
Total number of engines blown down..	179	203	197
Average steam pressure per engine on boiler at time of blowing down, lbs...	103	110	108
Average time taken per engine in blowing down, min..................	70	73⅓	78
Total number of engines washed......	177	189	181
Average temperature of washing water, degrees..........................	189	177½	177
Average time taken per engine in washing, min.........................	25	25½	27
Total number of engines filled........	174	222	223
Average temperature of filling water, degrees..........................	210	207¼	211
Average time taken per engine in filling, min............................	26	24⅓	24¾
Total number of engines fired up......	189	217	218
Average time taken per engine in firing up to 100 lb. steam, min...........	46	43	41
Average extra consumption of water per boiler washed out, gal	No record.	1753⅙	1732⅔

The condition under which these tests were made require that all the blow-off water from the locomotive boilers be utilized again for washing and refilling.

The average temperature of washing water obtained from the hot well is quite high. As the wash-out pump has two branches—one from the hot well and one from the cold water storage—the temperature of the water as it leaves the nozzle can be made to suit, which is maintained at as high a temperature as it is possible to work. This plant has been in service one year and no live steam has ever been used for heating water, as we always have available for refilling sufficient water of a temperature over 200°. The cost of boiler washing with this system is approximately as follows:

AVERAGE COST OF BOILER WASHING — HOT WATER SYSTEM.

Blowing steam and water out of boiler	1 man, 15 min.	@$0.22	$0.055
Remove and replace plugs	2 men, 30 min.	@ .22	.220
Washing boiler	2 men, ½ hr. ea.	@ .22	.220
Water used washing boilers	1 500 gal.	@ .08	.120
Water used filling boiler	No charge.		
Time filling boiler	1 man, 30 min.	@ .22	.110
Laying fire bed, 1 000 lb. coal (Bit.)		@2.00 net	1 000
Additional fuel to raise steam to 100 lb. pressure 500 lb. (Bit.)		@2.00 net	.500
Time of fire builder	1 man, 45 min.	@ .175 hr.	.131
			$2.356

The wash-out men in addition to washing boilers, also wash out the tanks on tender, and apply new tank hose where required.

We have found this plant very economical and have not spent anything for repairs to this plant during the past year.

The plant has a total water capacity of 60,000 gal., 30,000 gal. of which is in the hot well, 18,000 gal. in the refilling tank, and 12,000 gal. in the cold water storage.

Your committee has been furnished by courtesy of Mr. D. F. Crawford, G. S. M. P., of the Pennsylvania Lines West of P.ttsburgh, with copy of their standard instructions for washing boilers, and the tools referred to therein are shown following the instructions, which read as follows:

Use hot water wherever possible for washing and filling boilers. When cold water is used connect supply of cold water to injector feed pipe and introduce cold water through injector as boiler is being blown off, allowing water to run out as fast as it runs in until boiler is cool enough to permit the hand on side sheet. When cold water is used this should be continued until boiler is almost cold to the touch.

After boiler has been blown out all hand hole plates, plugs and mud pot caps must be removed. In case scale has accumulated around door ring and in water legs to a considerable amount, it may be advisable to make preliminary runs at these points. The crown sheet shall then be washed, using Nozzles Nos. 1 and 2, starting with long nozzle which shall be inserted through

opening at side until end is at front of crown sheet. Water shall then be turned on and scale on crown sheet washed to side and into water leg, nozzle being occasionally turned and gradually withdrawn so that the washing shall proceed from front of crown sheet toward rear, thus avoiding washing scale upon the flues. Nozzle No. 2 shall be used for washing rear of crown sheet, commencing where Nozzle No. 1 left off. The opposite side of crown sheet shall then be washed and a final run made through center opening to insure that no scale is left on crown sheet.

The door ring shall next be washed, using Nozzle No. 3. Nozzle No. 5 shall then be secured in rear mud pot by means of bracket and mud pot studs, and barrel of boiler thoroughly washed, nozzle being turned so that all parts of barrel are reached. Finally the water legs shall be thoroughly washed in all directions, using either Nozzle No. 3 or No. 4 as is most convenient.

Before any of the hand hole plates, plugs or mud pot caps are replaced, boiler washing inspector shall make a thorough inspection of all available parts of boiler, inserting torch made by wrapping waste saturated in oil on long wire. In case scale is found the boiler washers shall be instructed to make such additional runs as are necessary, after which the inspector shall again make inspection and in all cases he shall pronounce the boiler clean before the boiler washers are allowed to proceed, and he shall be held responsible for the condition of the boiler. The inspector shall also examine threads of wash-out plugs and threads in plug holes and see that they are in proper condition to insure tight plugs before being screwed in.

The hand hole plates, plugs and mud pot caps shall next be replaced, using graphite mixture on gaskets, and boiler refilled, using Nozzle No. 6 which shall be inserted in side of boiler so that hose will hang without kinking. It should not be necessary to tie nozzle in place.

The date when boilers are washed and initials designating place of washing must be stenciled on cab bracket by head boiler washer or inspector, in accordance with blue-print from tracing No. 6194-B.

To change water in boiler, proceed as outlined in first and second paragraphs of these instructions, until sufficient time has elapsed for all water to be replaced.

WATER TREATMENT TO PREVENT INCRUSTATION.

The Santa Fe, which has more water softening plants in operation than any other road, reported:

With the advent of the large modern locomotive and the requirements of maximum tonnage and minimum running time and the large amount of water evaporated per locomotive mile, came the necessity for water treatment. The Santa Fe went into the water treatment in the latter part of 1903, since that time 115 water treating plants have been established; these are all in main line and important branch lines and extend from Chicago to California, Texas and Colorado, having water treating plants in nine States.

The lowest incrustants before treatment in any water treated is 16.6 gr. per gal.

The highest incrustants before treatment is 80.9 gr. per gal.

Average cost of water treatment on the Santa Fe is 3¼ cents per 1000 gal.

Average amount of incrustants in all waters before treatment for 1912 was 31.6 gr.

The average amount of incrustants after treatment was 3.2 gr.

The average amount of incrustants removed was 28.4 gr.

The pounds of incrustants removed per 1000 gal. was 4.05 lb.

Total 1000 gal. treated, 4,050, 367.

Total pounds incrustants removed 16,708, 728.

The attached is a condensed summary of water treatment for the year 1913.

SUMMARY OF WATER TREATMENT, YEAR 1913.

DIVISION.	Grains Av. Incrustants. Before Treatment.	After Treatment.	Removed.	Lb. Incrts. Removed per M. Gal.	Total M. Gal. Treated.	Total Lb. Incrustants Removed.
Illinois	32.0	2.2	29.8	4.26	222 180	1 035 016
Missouri	26.6	3.0	23.6	3.37	154 225	601 703
Kansas City	46.9	4.5	42.4	6.06	260 188	1 576 739
Eastern	27.5	3.3	24.2	3.46	447 852	1 496 738
Total Eastern Lines, E. D.	33.3	3.3	30.0	4.19	1 084 445	4 710 196
Middle	33.0	3.6	29.4	4.20	195 576	905 429
Oklahoma	39.5	3.9	35.6	5.09	199 683	988 354
Total Eastern Lines, W. D.	36.3	3.8	32.5	4.64	395 259	1 893 783
Total Eastern Lines	34.8	3.6	31.2	4.46	1 479 704	6 603 979
Western	31.3	2.6	28.7	4.10	186 861	666 145
Arkansas River	50.0	3.3	46.7	6.67	224 646	1 821 705
Colorado	49.7	3.2	46.5	6.64	141 090	599 683
New Mexico	40.4	3.2	37.2	5.31	224 581	866 876
Rio Grande	31.0	3.5	27.5	3.93	219 033	811 073
Total Western Lines, N. D.	40.5	3.2	37.3	5.33	996 211	4 765 482

SUMMARY OF WATER TREATMENT, YEAR 1913—Concluded.

DIVISION.	Grains Av. Incrustants. Before Treatment	After Treatment.	Removed	Lb. Incrts. Removed per M. Gal.	Total M. Gal. Treated.	Total Lb. Incrustants Removed.
Pan Handle...........	40.5	3.1	37.4	5.34	92 116	414 827
Plains................	27.9	2.4	25.5	3.64	156 734	641 832
Pecos................	40.6	3.0	37.6	5.37	98 616	537 419
West Lines, S. D......	36.3	2.8	33.5	4.79	347 466	1 594 078
Western Lines.........	38.4	3.0	35.4	5.06	1 343 677	6 359 560
A. T. & S. F. Proper...	36.6	3.3	33.3	4.76	2 823 381	12 963 539
Albuquerque..........	34.0	3.2	30.8	4.40	299 398	1 160 289
Arizona..............	25.2	2.2	23.0	3.29	429 563	1 332 571
Los Angeles...........	23.5	2.3	21.2	3.03	485 725	1 176 789
Valley................	22.3	3.8	18.5	2.64	22 549	59 529
Total Coast Lines....	26.3	2.9	23.4	3.34	1 237 235	3 729 178
Total A. T. & S. F. System, 1913......	31.5	3.1	28.4	4.06	4 060 616	16 692 717
A. T. & S. F. System, 1912.............	31.6	3.2	28.4	4.05	4 050 367	16 708 728
A. T. & S. F. System, 1911.............	30.6	3.5	27.1	3.87	3 958 637	14 887 633
A. T. & S. F. System, 1910.............	31.6	3.6	28.0	4.00	3 898 838	15 284 164
A. T. & S. F. System, 1909.............	35.4	3.7	31.7	4.52	3 149 942	13 063 320
A. T. & S. F. System, 1908.............	35.8	3.9	31.9	4.55	2 642 978	11 102 859
A. T. & S. F. System, 1907.............	32.6	4.3	28.3	4.03	2 466 965	9 579 772
A. T. & S. F. System, 1906.............	35.0	4.1	30.9	4.41	1 913 398	7 906 233

The incrusting matter in boiler waters consists almost entirely of carbonates of lime and magnesia and sulphates of lime and magnesia. The carbonates require treatment with hydrated lime and the sulphates require soda ash. Most roads have a great variety of boiler waters and a large number of different chemicals have been brought forward by commercial concerns for treating them, but in view of the additional cost, etc.,

they have finally eliminated all chemicals but lime and soda ash for commercial work. The proportion varies to suit the relative amounts of sulphates and carbonates.

Any system of water softening to be effective must work within certain prescribed limits, such as automatic means of proportioning the correct amount of chemicals to the water should be provided. The water should have not less than four hours' time in which to complete the reaction and settle out the precipitates from the time it enters the treating tank until it overflows into the storage tank. Ample provision must be made for removing the precipitates soon after they are deposited so that they will not be roiled up by the incoming water, and usually it is thought desirable to add some kind of a filter so as to be sure that perfectly clear and sparkling water is furnished the locomotives at all times.

There are two general classes of water softening plants on the market: one known as the "Continuous" and the other as the "Intermittent" system. In the Continuous system the water and chemicals flow into the treating tank simultaneously, and this tank is of sufficient height so that the clear filtered water will flow by gravity into the storage tank; whereas with the Intermittent system the water and chemicals are admitted into one or more tubs and after the percipitates have subsided the water is then pumped into the storage tank. There are advantages in both systems, but on the whole it is considered that the Continuous system is preferable on account of requiring less floor-space and also less labor and fuel charges for the additional pumping.

Few realize the extent of the problem put up to the chemist when we tell him to treat the water. We often hear the statement that a certain boiler water is 95 or even 99 per cent pure. As a matter of fact a water which is 99.9 per cent pure would be a very unsatisfactory boiler water as a rule.

We work to less than 1-100 of 1 per cent; that is, there are 58,320 gr. in one U. S. gallon; 1-100 per cent means 5.83 gr., and the average water softening plant will reduce the incrusting matter to four or less grains per gallon. This means that we are working to almost theoretical limits, and inasmuch as some of the surface waters from rivers, ponds, etc., are continually changing their composition it becomes necessary that sufficient supervision be given these plants. In extreme cases the incrustants of certain waters have been known to fall from 60 down to 11 gr. in an hour's time. Wherever possible the pumper is supplied with the necessary apparatus and instructed in the method of making simple tests so that treating of these changeable waters will not "get off" too far between visits of the regular chemist.

There are a number of factors which should be considered when deciding whether or not to build a water softening plant. As a rule little is gained by putting up a single plant here and there over the division. Treatment of only a small fraction of the waters can not possibly result in the preventing of the formation of all scale, and these plants always get the blame for any foaming troubles which arise on that division, whether justly or not. On the other hand it is sometimes advisable to erect a treating plant even at one of the minor stations in order that all the waters on a certain division may be uni-

form, thereby making it impossible for the engineer to run the treated water stations.

As previously stated, all regular water treating plants, except one or two on the Santa Fe are in main line service. On some of the branch lines where the quantity of water used is small, soda ash is applied to the engine's tender. This has proven beneficial in almost every case that it has been tried, the difficulty being to get the soda ash applied regularly and in the proper amounts.

Soda ash applied in an engine tender has this disadvantage, that the water in the engine's tender becomes partly treated and will, with high sulphate, throw down its solids at a reasonably low temperature, and in many cases the temperature of the injector is sufficient to do this and the result is rapid incrustation of injector, injector parts, and connections, and increase of injector troubles. This tender treatment is therefore a very poor substitute for water softening plants, but will to a certain extent relieve the situation on those branch lines where the waters are only moderately hard.

It is our observation, while at present we do not treat water that contains less than 16 gr. per gallon, that it would be profitable, where much water is used, to treat it when the incrusting solids exceed twelve grains per gallon, this is especially desirable where treated waters may be on both sides of one of these untreated water tanks, for the reason that the incrusting solids in the untreated water, after they are precipitated, greatly add to the sludge and aggravate foaming conditions. It is our experience that the use of treated waters does not decrease the foaming tendency, but rather increases it, and on that account we can not say that it decreases the frequency of wash-outs and water change, but it does give us clean boilers when we do wash them, for two reasons:

First. Because the incrusting matter has been nearly all removed from the water.

Second. That small portion which was not removed, on account of the action of the treating chemicals, is precipitated in the form of sludge and little or no scale is formed, a condition which, before water treatment, was impossible to maintain. It is our experience where scale is being formed, the water is not being sufficiently treated.

Benefits of Water Treatment.

The beneficial results of following water treatment may be approximately shown by the increase in flue mileage between failures since the beginning of water treatment in 1903. The mileage between flue failures on the Santa Fe System on account of leaking for the last eight months in 1903 was 17,557 miles. This has shown a steady increase until for the first eight months for 1914 the mileage per flue failure was 168,624 miles.

The following statement shows the improvement in flue failures for the Santa Fe System since the last eight months of 1903 up to and including the first eight months of 1914. A very stricking improvement of one Grand Division is shown by their making 13,719 miles between flue failures on account of leaking in 1906, the same Grand Division making 258,833 engine-miles per flue failure during the first eight months of 1914.

FLUE FAILURES — SANTA FE SYSTEM.

Year.	Flue Failures.		Total Engine Mileage.	Miles per Failure Acct. Flues Leaking.
	Leakage.	Bursted.		
1903	1 054	56	18 505 800	17 557
1904	1 318	89	27 622 809	20 958
1905	1 236	113	32 725 635	26 477
1906	1 930	240	45 893 460	23 779
1907	1 798	275	49 543 360	27 554
1908	1 115	234	44 662 442	40 056
1909	1 108	333	50 259 138	45 360
1910	1 163	301	57 090 170	49 088
1911	741	235	55 651 648	75 103
1912	779	270	56 856 676	72 986
1913	472	223	55 590 954	77 616
1914	211	140	35 579 841	168 624

Record for 1903 last eight months.
Record for 1914 first eight months.

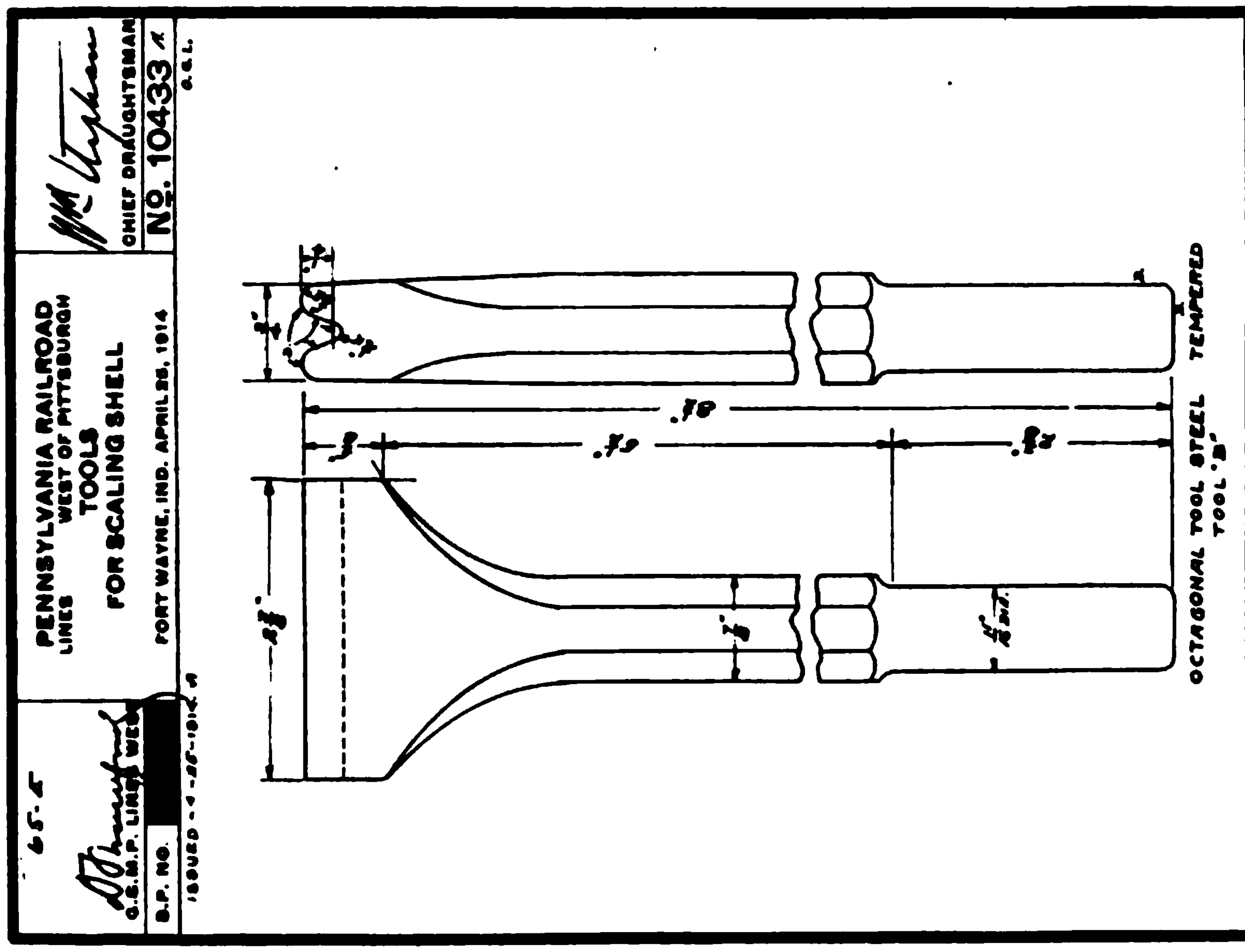
The above miles per failure is on account of flue leaking. Flue bursted is not figured in. It is assumed that the flues bursted is largely unavoidable.

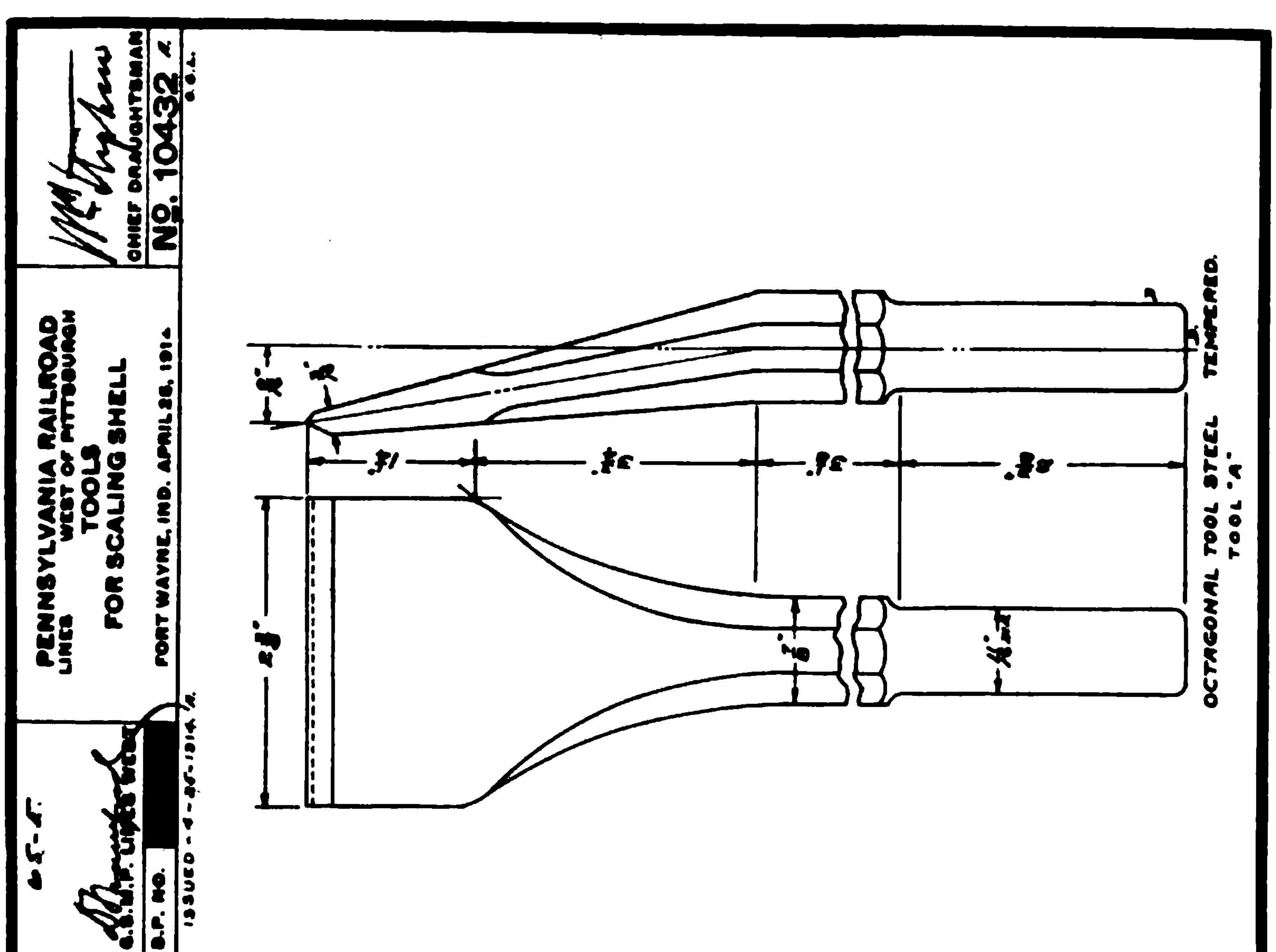
We can not give such definite figures on the life of our fire boxes, but it is safe to say that water treatment has in many cases increased the life of fire boxes 300 per cent, it being considered that the improvement in the flue performance represents very largely a correspondingly improved performance in fire-box sheets.

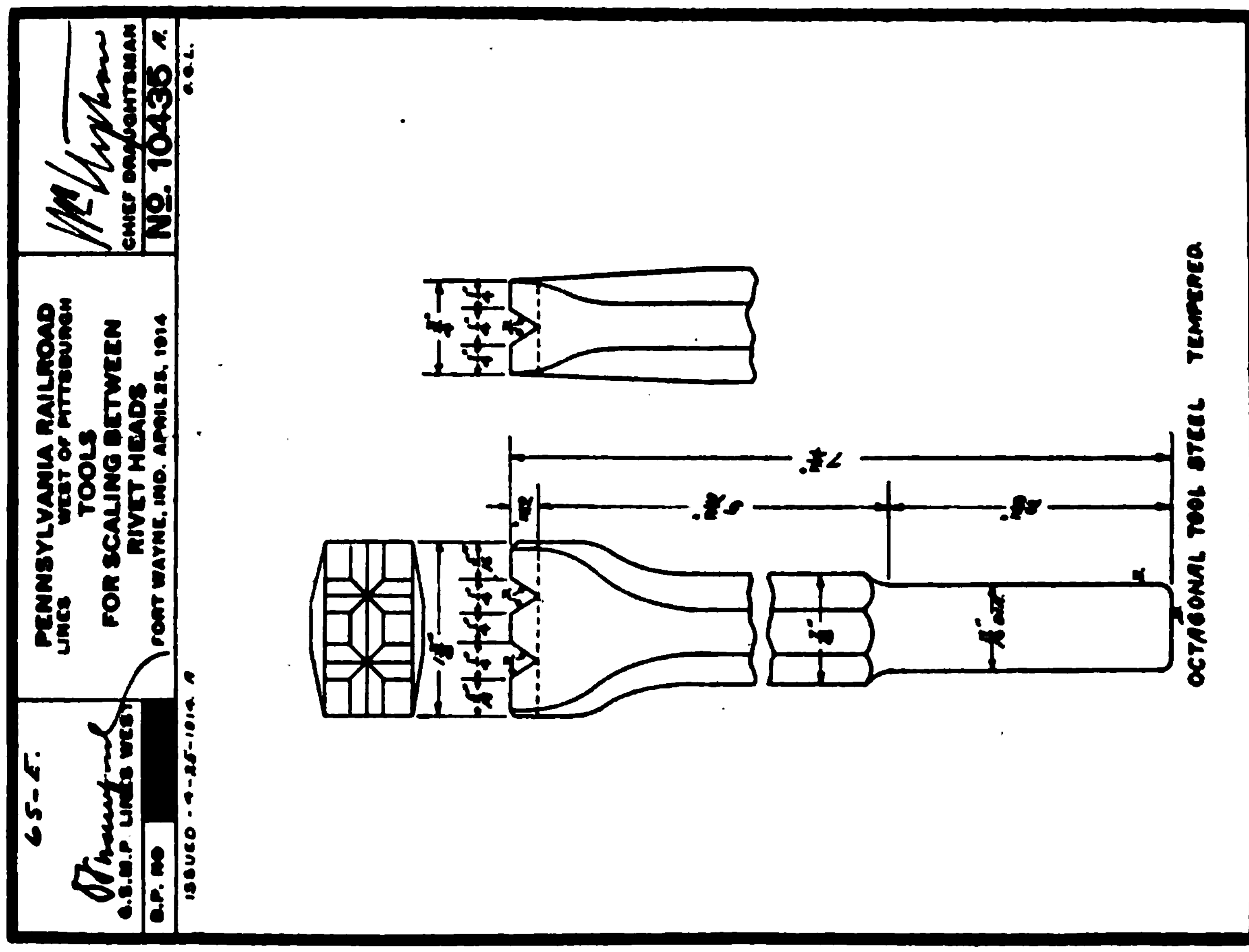
Respectfully submitted,

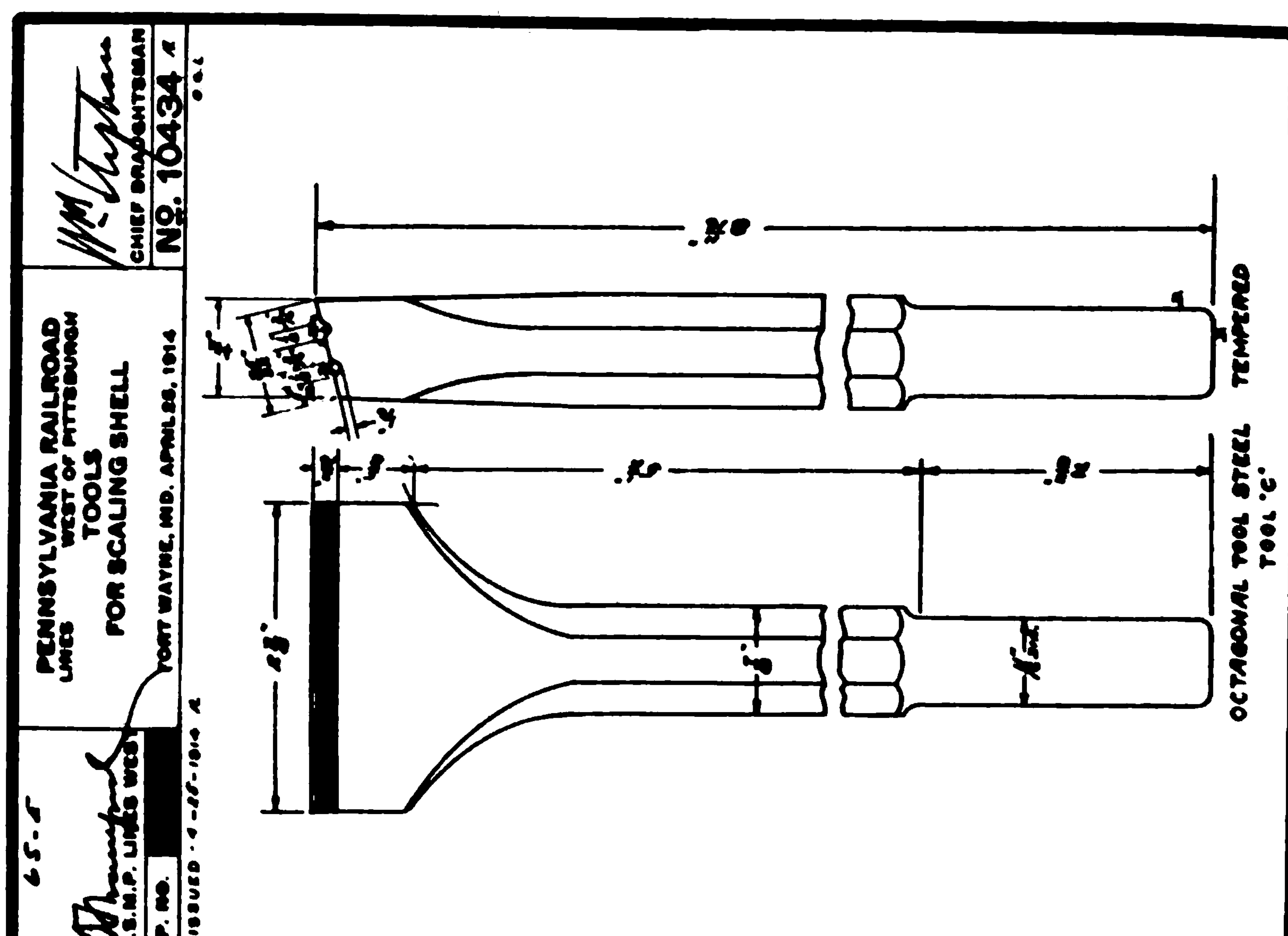
JOHN PURCELL, Chairman.
W. H. FETNER,
J. C. LITTLE,
W.P.CARROLL,
G. W. RINK,
E. S. FITZSIMMONS,
G. E. SISCO,

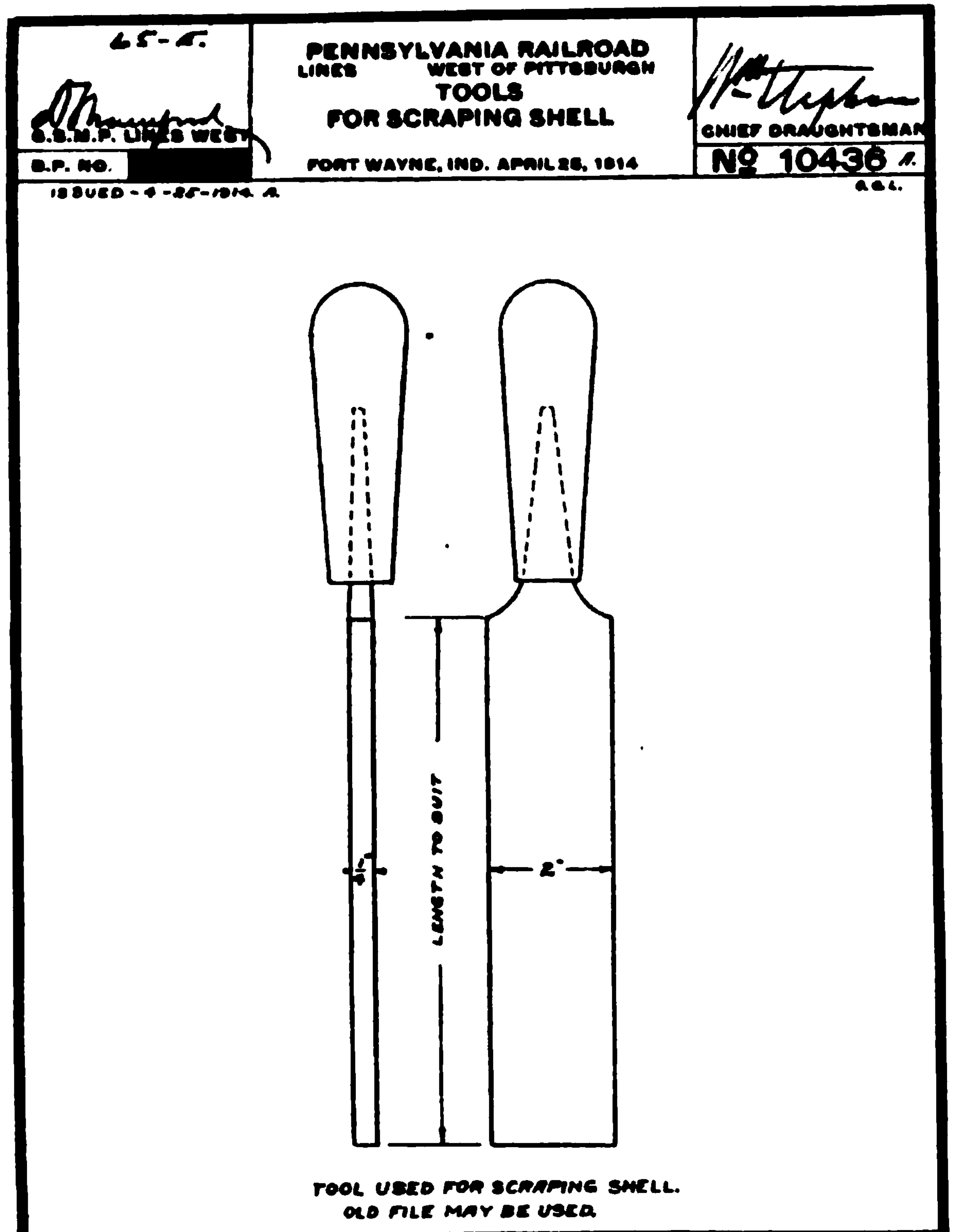
Committee.

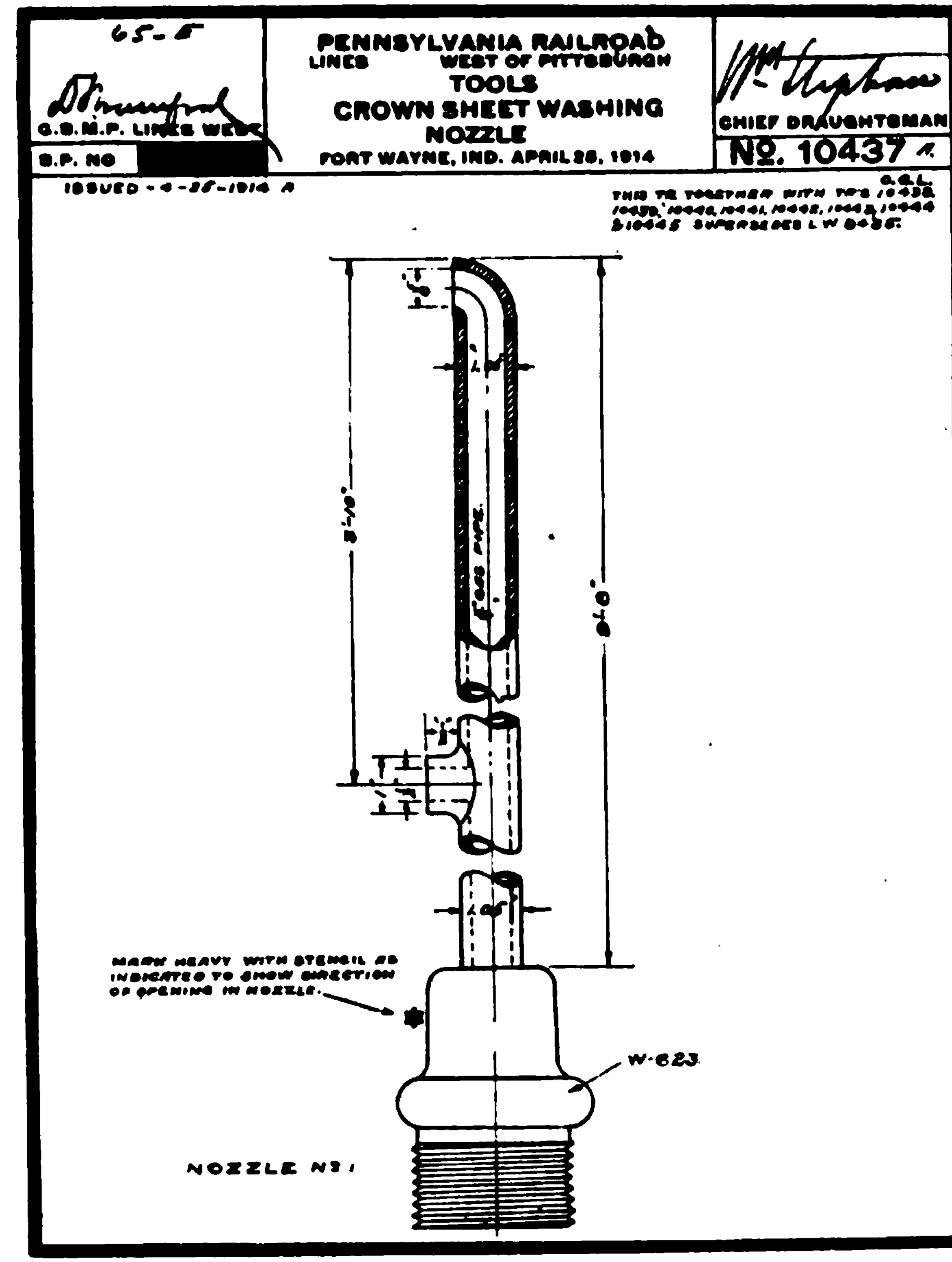

PENNSYLVANIA RAILROAD
LINES WEST OF PITTSBURGH
TOOLS
FOR SCALING SHELL
FORT WAYNE, IND. APRIL 25, 1914
CHIEF DRAUGHTSMAN
NO. 10433 A
G.S.M.P. LINES WEST
B.P. NO.
OCTAGONAL TOOL STEEL TEMPERED
TOOL 'B'

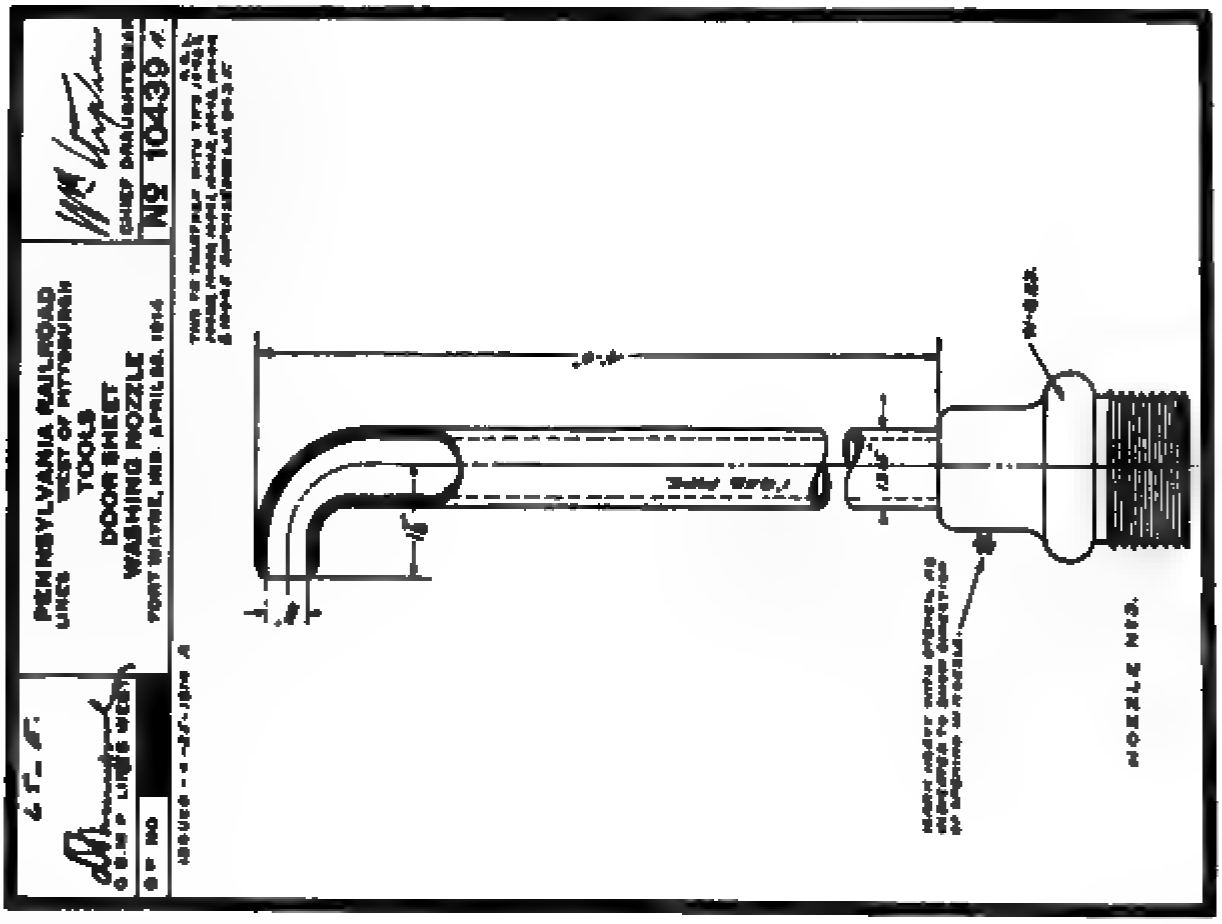

PENNSYLVANIA RAILROAD
LINES WEST OF PITTSBURGH
TOOLS
FOR SCALING SHELL
FORT WAYNE, IND. APRIL 25, 1914
CHIEF DRAUGHTSMAN
NO. 10432 A
G.S.M.P. LINES WEST
B.P. NO.
OCTAGONAL TOOL STEEL TEMPERED.
TOOL 'A'

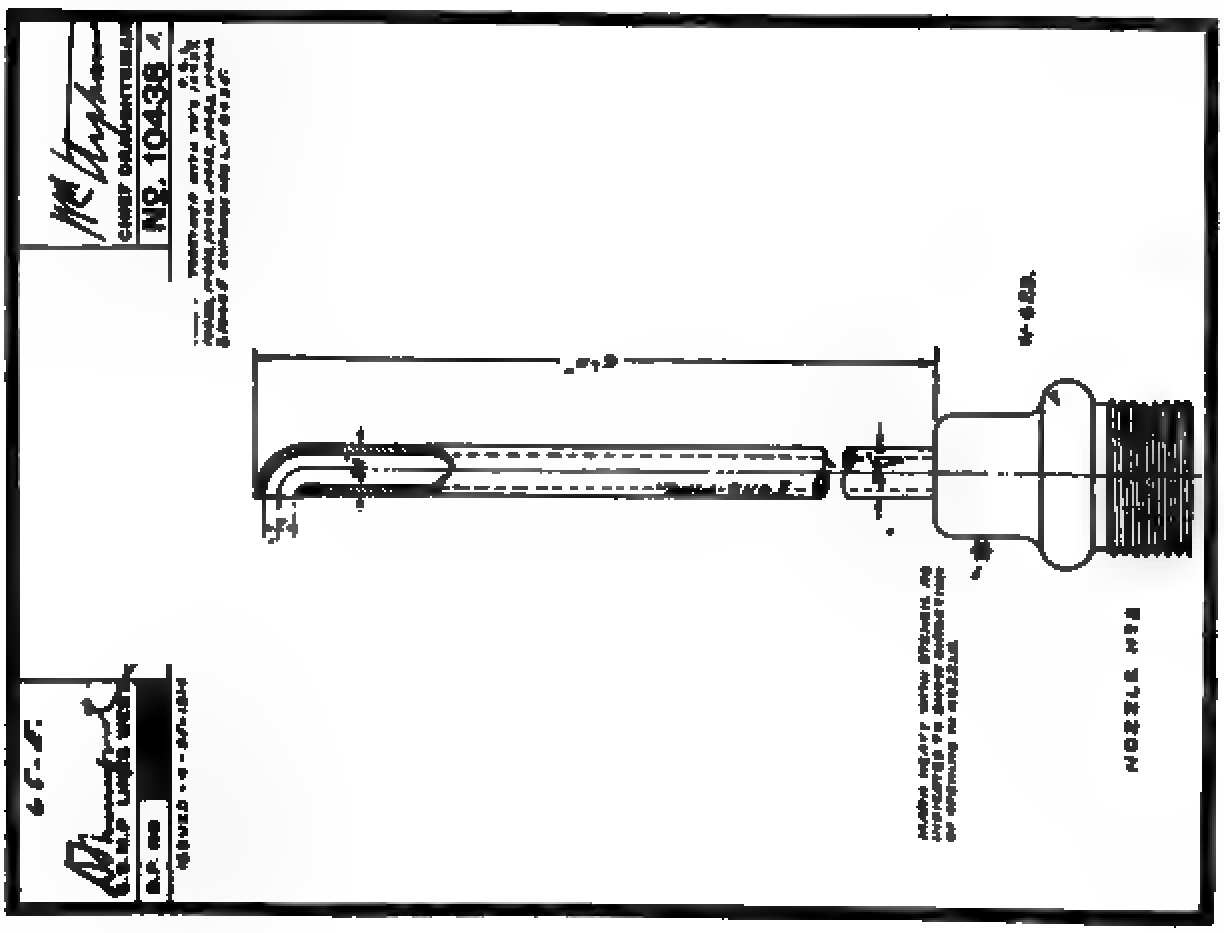

65-E.
G.S.M.P. LINES WEST
B.P. NO
ISSUED 4-25-1914 R
PENNSYLVANIA RAILROAD
LINES WEST OF PITTSBURGH
TOOLS
FOR SCALING BETWEEN
RIVET HEADS
FORT WAYNE, IND. APRIL 25, 1914
CHIEF DRAUGHTSMAN
No. 10435 R
G.C.L.
OCTAGONAL TOOL STEEL TEMPERED

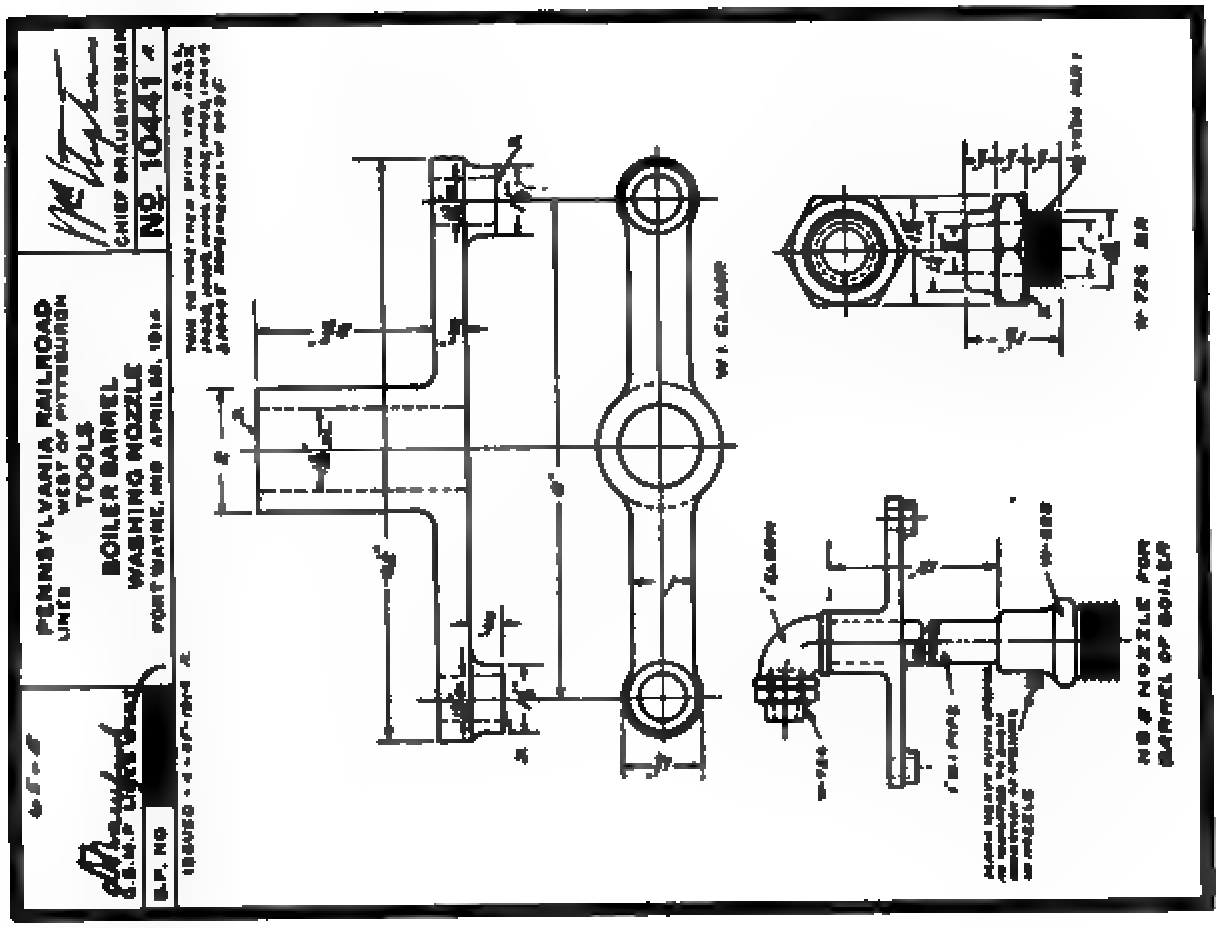

65-F
G.S.M.P. LINES WEST
B.P. NO.
ISSUED 4-25-1914 R
PENNSYLVANIA RAILROAD
LINES WEST OF PITTSBURGH
TOOLS
FOR SCALING SHELL
FORT WAYNE, IND. APRIL 25, 1914
CHIEF DRAUGHTSMAN
No. 10434 R
G.C.L.
OCTAGONAL TOOL STEEL TEMPERED
TOOL 'C'


65-E.
G.S.M.P. LINES WEST
B.P. NO. [redacted]
PENNSYLVANIA RAILROAD
LINES WEST OF PITTSBURGH
TOOLS
FOR SCRAPING SHELL
FORT WAYNE, IND. APRIL 28, 1914
CHIEF DRAUGHTSMAN
Nº 10436 A.
ISSUED - 4 - 25 - 1914. A.
G.G.L.
LENGTH TO SUIT
2"
TOOL USED FOR SCRAPING SHELL.
OLD FILE MAY BE USED.

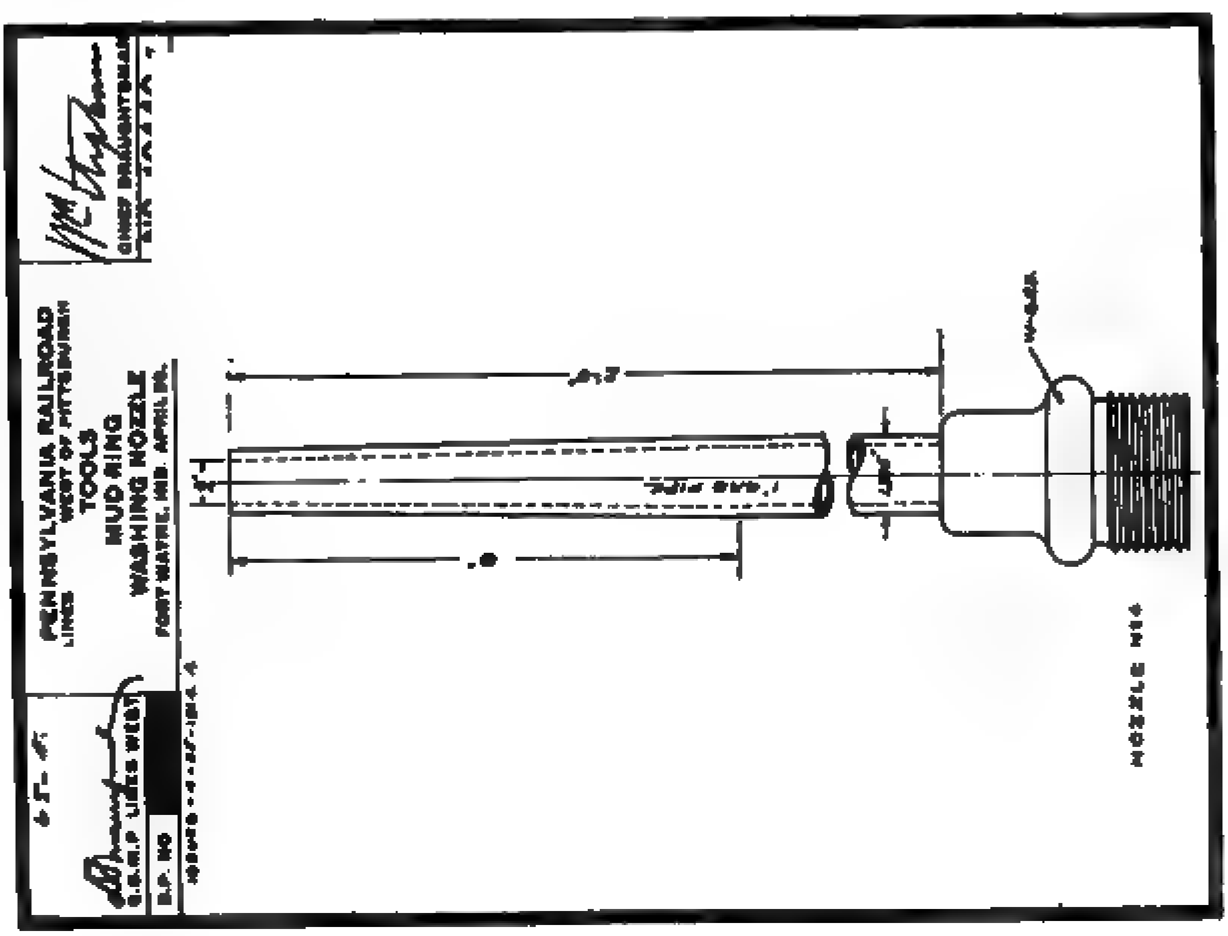

65-E
G.S.M.P. LINES WEST
B.P. NO [redacted]
PENNSYLVANIA RAILROAD
LINES WEST OF PITTSBURGH
TOOLS
CROWN SHEET WASHING
NOZZLE
FORT WAYNE, IND. APRIL 28, 1914
CHIEF DRAUGHTSMAN
Nº. 10437 A.
ISSUED - 4 - 25 - 1914 A
G.G.L.
MARK HEAVY WITH STENCIL AS INDICATED TO SHOW DIRECTION OF OPENING IN NOZZLE.
W-623
NOZZLE Nº 1


PENNSYLVANIA RAILROAD
LINES WEST OF PITTSBURGH
TOOLS
DOOR SHEET
WASHING NOZZLE
CHIEF DRAUGHTSMAN
Nº 10439 A

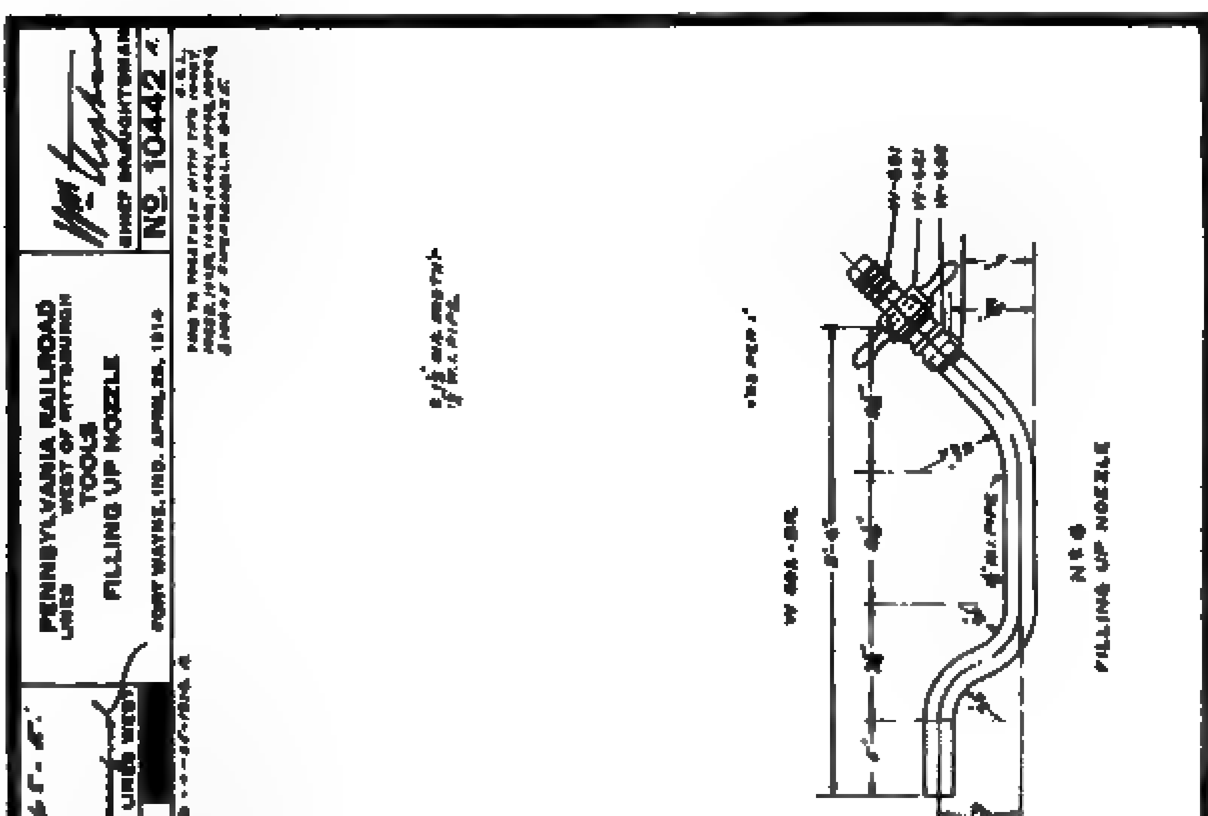

CHIEF DRAUGHTSMAN
Nº 10438 A

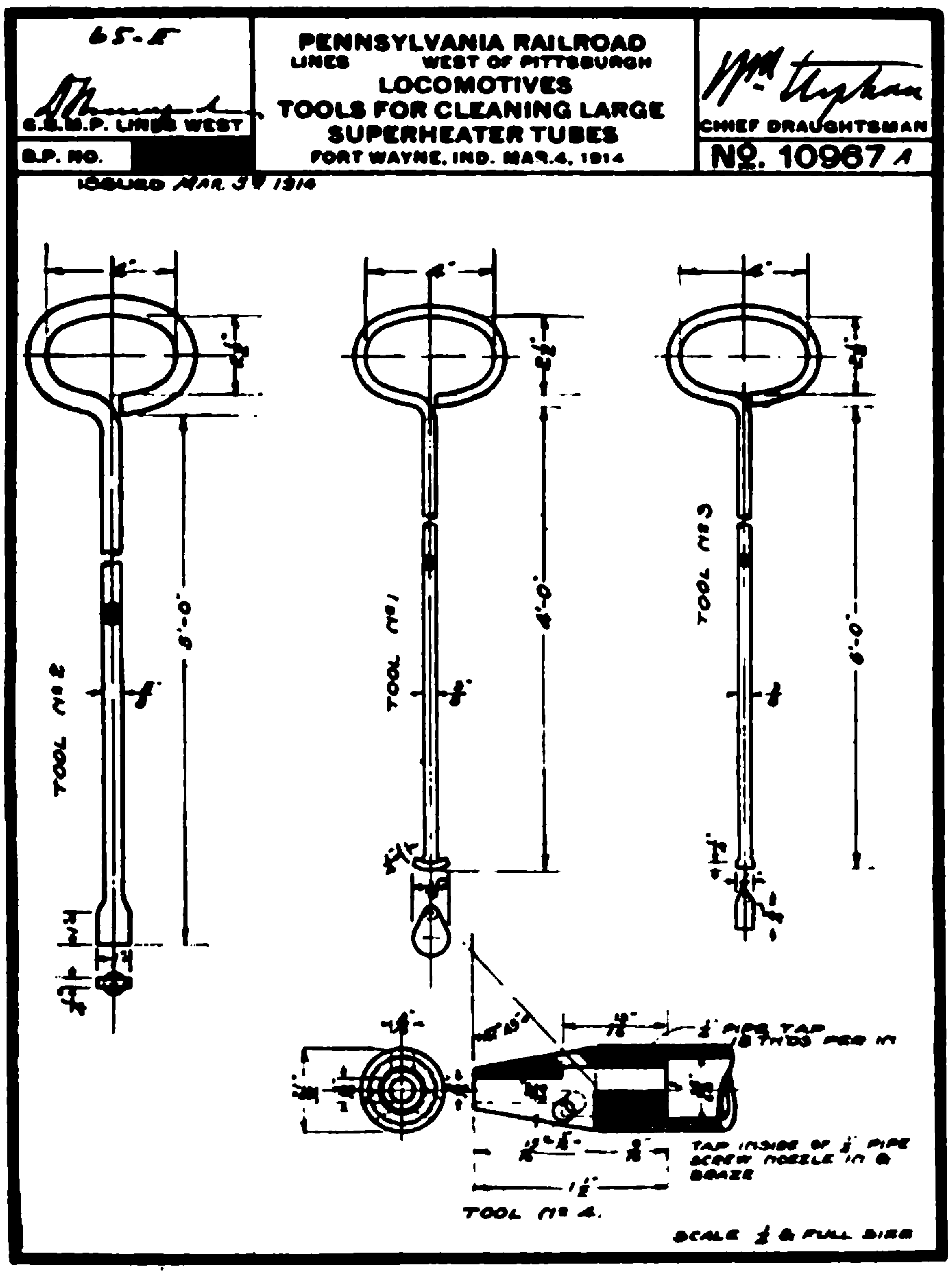


PENNSYLVANIA RAILROAD
LINES WEST OF PITTSBURGH
TOOLS
BOILER BARREL
WASHING NOZZLE
FORT WAYNE, IND. APRIL 28, 1914
CHIEF DRAUGHTSMAN
NO. 10441 A
W.I. CLAMP



PENNSYLVANIA RAILROAD
LINES WEST OF PITTSBURGH
TOOLS
MUD RING
WASHING NOZZLE
CHIEF DRAUGHTSMAN


PENNSYLVANIA RAILROAD
LINES WEST OF PITTSBURGH
TOOLS
FILLING UP NOZZLE
FORT WAYNE, IND. APRIL 25, 1914
CHIEF DRAUGHTSMAN
No. 10442
FILLING UP NOZZLE



THE CHAIRMAN: If there is no objection, the paper will be received and opened for discussion.

MR. DUNHAM: For those of us who have to deal with particularly bad water conditions, it hardly seems as if it would be necessary to outline a series of rules or set of rules, as presented here, but that is the fact. It was my experience, not very long ago, to outline a set of rules very similar to these. The results obtained from being systematic and thorough in washing out of boilers, even though you are not equipped with the latest and most expensive equipment of hot-water washout plants, and all such details, indicate that it is all well worth while.

To hark back to engine failures or delays. By systematically washing and having, as was indicated on page 11, at the top of

the page, some one inspect the work after it was done who is not directly in charge of the work (I have usually specified that the roundhouse foreman of either the day or night force should inspect the boiler after it was washed out), we have been able to eliminate flue failures and fire-box failures where we had them before, and had lots of them.

I believe the rules which have been laid down here are most excellent. There is only one variation which I found necessary from the plan here outlined, and that is, under our local conditions, we have found it very necessary to wash from the front of the boiler back through the flues first, and then follow the procedure practically as Mr. Purcell has outlined it here.

We have a very heavy accumulation of mud and scale, and we believe it is advisable to get that off the flues first, and then we finish up with that the last. In other words, we give our flues a double washing, you might say, and we find it pays exceedingly.

Mr. MacBain: Mr. Chairman, the importance of good washing-out I do not believe would be questioned by any person, excepting some Superintendent or Trainmaster who thought the engine did not need washing out, and the progress that has been made in the past ten years in that very important part of the maintenance of the locomotive is something I am sure every member of the Association appreciates.

There was a time when the washing-out of boilers was given so little attention that it was a crime almost, and the papers that were started in this Association about ten years ago began to wake everybody up to the necessity of giving every attention to that apparently perfunctory operation.

I just wish to say that the paper presented by the committee on this subject at the present time might be taken safely by any member of the Association as a text, and I wish to say further that, following it in the finest detail outlined, you will not be going too far so far as the interest of the company is concerned.

As the time is growing short, as it is growing toward closing time, and as there is a lot yet to do, I would move you that the paper be accepted as read, and a vote of thanks extended to the committee for the work they have done.

THE CHAIRMAN: Mr. MacBain, what would be your idea of the Association using these instructions as recommended practice?

MR. MACBAIN: Yes, sir; I would recommend that they be used as recommended practice.

THE CHAIRMAN: Will you include that in your motion?

MR. MACBAIN: Yes.

THE CHAIRMAN: To refer it to letter ballot as recommended practice?

MR. MACBAIN: Yes, sir.

MR. DUNHAM: I would like to add one suggestion in that connection, not to stall any move of that kind, because I think it is a good thing, but references are made to certain nozzles there that add details of instruction. If the wording of the outline could be changed so that nozzles No. 1 and No. 2 would not be designated that way, but would be a "right-angled nozzle" or a "straight nozzle," or something of that kind, it would be of more general application than the detail outlined here. With that change, I would second Mr. MacBain's motion.

MR. MACBAIN: That is agreeable.

Motion carried.

THE CHAIRMAN: Is there any further discussion?

MR. O. C. WRIGHT (Penna. Lines): Mr. President, I would like to call attention to the illustration on page 9 covering the boiler-inspection electric lamp. This illustration shows a brass socket connected to a piece of wrought-iron pipe. I would like to say that we have had some experience with a similar inspection lamp and have found that on account of the fact that the lamp is subjected to moisture and mechanical abuse it was almost impossible to keep it free from grounds, making it a very unpleasant as well as a rather dangerous lamp to handle. We have designed and are using a lamp of very similar construction to this exhibit, but with a porcelain socket sealed in and attached to a fiber tube. We have gotten very good results from this lamp,

and it has eliminated the objectionable features of the lamp with the brass socket.

THE CHAIRMAN: Are there any further remarks? The committee might wish to consider some suggestions from the floor before the paper is printed.

MR. GILES: I would like to suggest that a vote of thanks be extended to the Committee on Counterbalancing for the very able report they have prepared. I am sure that it required a great deal of detail work; also especially to Mr. Thomson, the chairman, for the manner in which he presented it.

MR. MACBAIN: I will take pleasure in seconding that motion.

Motion put to vote and carried.

THE CHAIRMAN: The next subject is the report of the Committee on Dimensions for Flange and Screw Couplings for Injectors. Mr. M. H. Haig, M. E., A. T. & S. F. Ry., is chairman.

Mr. Haig presented the report, as follows:

REPORT OF COMMITTEE ON DIMENSIONS FOR FLANGE AND SCREW COUPLINGS FOR INJECTORS.

To the Members:

At the 1914 convention Mr. O. M. Foster, Master Mechanic of the New York Central Lines, delivered a comprehensive paper on dimensions for flange and screw couplings for injectors. The information presented by this paper pointed to the need of standards for these dimensions and in concluding his paper Mr. Foster recommended the appointment of a committee to make recommendations on such standards.

In proposing standard dimensions for flange and screw couplings for injectors the committee has based its proposed standards on forms and dimensions which it believes will agree most nearly with the greatest number of couplings already in service. The committee has endeavored to decide upon standards which can be adopted for locomotive service with the least inconvenience and expense upon railroads and manufacturers. It believes that the tables and diagrams forming a part of this report show dimensions for couplings according to which injector connections of the future can be manufactured and maintained without confusion and with minimum expense incident to the adoption of any standard common to all railroads and manufacturers.

In collecting information on which to base its recommendation, the committee requested certain facts from railroads, locomotive builders and injector manufacturers. The information and comments received by the committee included statements of equipment in service as well as personal opinions and indicated conditions affecting injector equipment. These have governed largely in determining the proposed standards.

FORM AND DIMENSIONS OF THREADS.

The pitch of thread for injector couplings reported as used by the greatest number of roads is ten threads per inch. Analysis of the statements of the roads which communicated with the committee, investigation into the prints received from railroads and coöperation with the injector manufacturers, led to the conclusion that this pitch could be adopted as a future common standard with the least expense to all concerned.

Couplings made by different manufacturers and having approximately the same diameter as well as the same pitch of thread, will largely interchange at present. It was, therefore, decided that a thread adopted as standard should interchange with either a sharp V thread or with the U. S. standard thread. A modified form of the U. S. thread will meet this requirement and is suggested as the proposed standard. The form and dimensions of this proposed thread are shown by the accompanying Table 1.

These threads are proposed for all injector connections, including the overflow, as well as for all couplings used throughout the injector piping system, whether of the nut or flange type.

DIMENSIONS OF COUPLING NUTS AND SLEEVES.

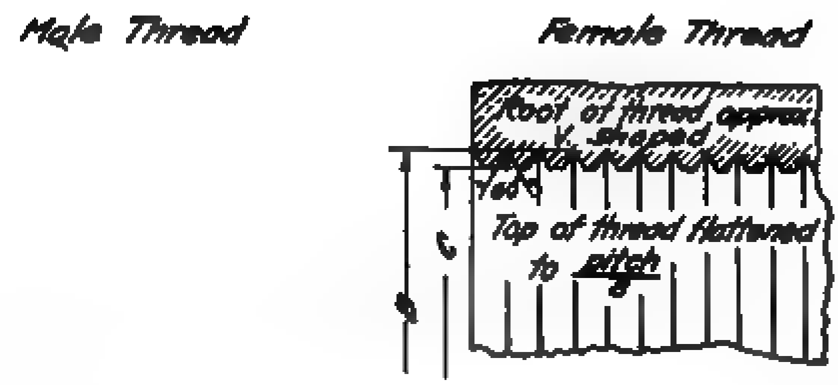
Copper and iron pipes used with locomotive injectors are included among a comparatively limited number of sizes. The pipe sizes for steam, water, delivery and overflow advertised by the various manufacturers as used with their several makes of injectors have been investigated. The sizes reported by the different railroads have been compared. These pipe sizes have further been considered in connection with the various sizes of couplings in use. As a result of this investigation it is believed that certain sizes of nuts can be selected as standard for certain sizes of iron and copper pipe. On the same principle it is believed that certain sizes of sleeves (collars or tail pieces) can be adopted as standard for use with definite sizes of nuts and pipes. The proposed standard dimensions of these coupling nuts and sleeves are shown by Diagram 1. The proposed standard forms of the nuts and sleeves are shown by Diagram 2.

Careful consideration of the diameter of couplings, as well as the sizes of pipes, used by various manufacturers led to the conclusion that it would not be practical to attempt a universal set of sizes or capacities of

TABLE I

PROPOSED STANDARD FORM AND DIMENSIONS OF THREADS FOR INJECTOR COUPLINGS

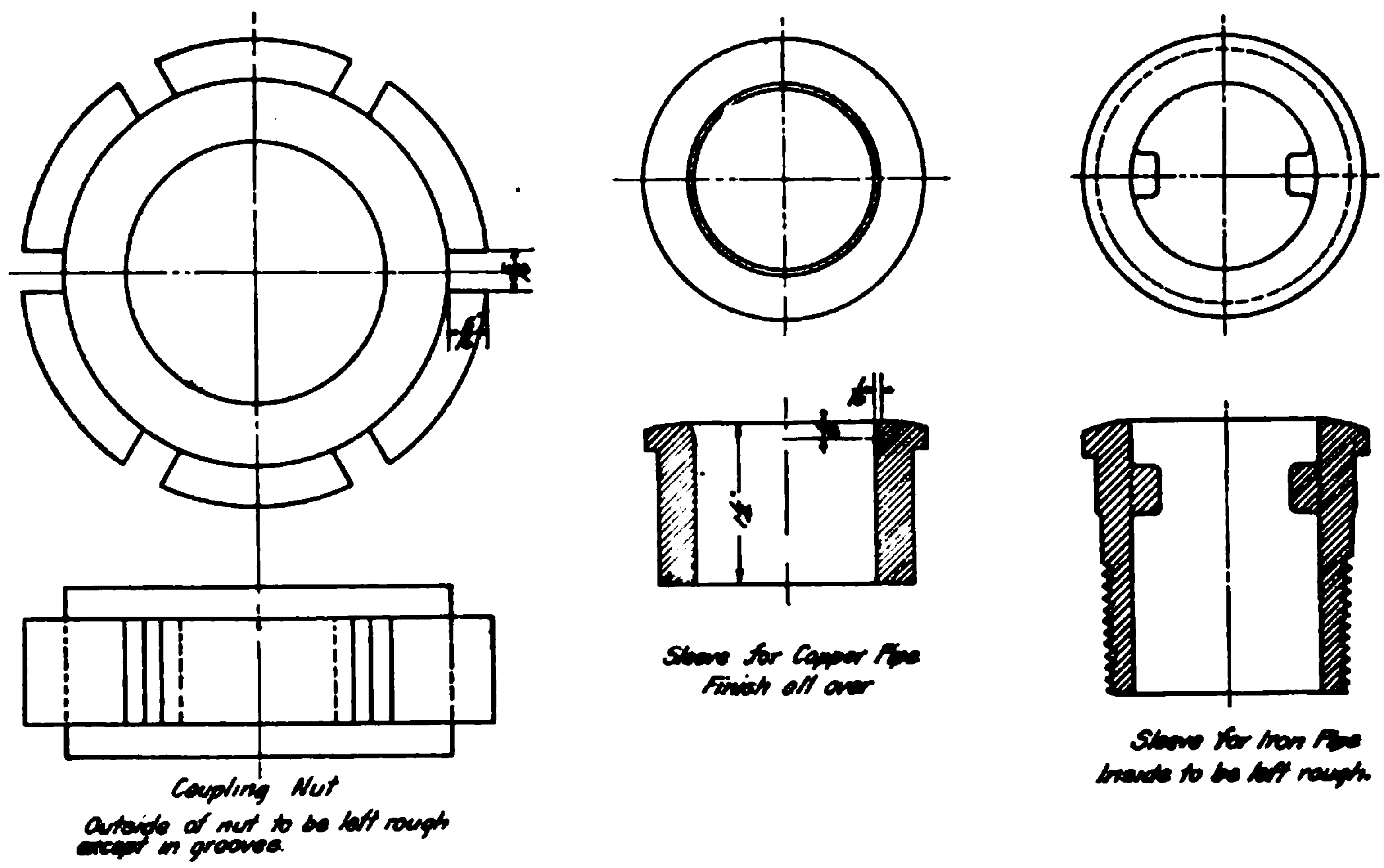
Ten Threads per Inch.



Pipe Size Inches		Nominal Size of Thread Inches	Thds. per Inch	Outside Diameter of Flattened Male Thd. A		Outside Dia. of Sharp "V" in Female Thd. B	
Iron	Copper			Maximum Inches	Minimum Inches	Maximum Inches	Minimum Inches
1		1¾	10	1.728	1.723	1.756	1.750
1¼	1¼	2"	10	1.971	1.966	1.998	1.993
1½	1½	2⅜"	10	2.375	2.370	2.402	2.397
1½"	1¾	2 25/32	10	2.796	2.791	2.823	2.818
2"	2	3	0	3.009	3.004	3.036	3.031
2"	2¼	3	10	3.009	3.004	3.036	3.031
2½"	2½	3½	10	3.488	3.483	3.515	3.510
3	2¾, 3¼	4⅛	10	4.103	4.098	4.130	4.125

A max. = B min − .022
A min. = A max. − .005
B max. = B min + .005
C = B − .151

DIAGRAM 2.
PROPOSED STANDARD FORMS OF COUPLING NUTS AND SLEEVES
Dimension of nuts and sleeves to be according to Diagram 1.



injectors to which all manufacturers should conform, or a set of common pipe or coupling sizes for each size or capacity of injector. Instead it is proposed that each manufacturer shall continue the size of pipe considered most satisfactory for his injector, but the couplings for each size of pipe shall conform to the proposed standard threads and dimensions.

Unfortunately, injector nuts are sometimes subject to rough handling by tightening them with improper tools. To resist improper handling and to provide against nuts being stretched by tightening or cracked by pounding, the proposed standards include dimensions for greater thickness throughout than found common in past practice. The outside dimensions should, therefore, be followed with almost the same strictness as the inside dimensions when manufacturing coupling nuts. The skin which forms on the outside of a brass casting contains a certain amount of strength which is lost when this skin is turned off. It is, therefore, proposed that the outside of injector coupling nuts shall be left rough, except in the grooves.

In planning proposed standard dimensions for sleeves, various sizes were considered by which it might be possible to make the sleeves thicker. This detail was investigated at some length. Throughout the entire preparation of this report the committee has worked with the idea of proposing standards which can be adopted as common practice. To attain this end and lead to proposed standards actually being used, it has realized that radical changes from past practices will not be practical.

Making the sleeves thicker than in the past would increase their diameter. This in turn would require a greater diameter of nuts used

with given sizes of pipe. Such increases in diameter of nuts would prevent interchangeability with previous equipment where interchangeability between proposed standards and much old equipment would otherwise be possible.

For ready reference Diagram 1 is arranged to show the thickness of the various proposed sleeves. Where possible, this is shown by common fractions. With the possible exception of the sleeve for 1½-in. copper pipe it is believed that the sleeves shown for use with copper pipes are of reasonable thickness. Injectors on locomotives in present railroad service are seldom, if ever, equipped with 1½-in. copper pipe. This size, in all probability, will gradually become obsolete. The committee, therefore, does not regard it as of sufficient importance to justify any radical change.

APPLICATION OF COUPLING SLEEVES.

The committee favors copper pipe extending throughout the full length of the sleeve under all conditions. Recent practice on a few roads is to extend the copper pipe through the sleeve and bead it over the flange of the sleeve, thus forming the joint at the connection. In addition the pipe is rolled into the sleeve. A further support for the pipe is sometimes provided by rolling it into grooves in the sleeve. This application has been called a mechanical joint and the pipe is not brazed.

When the pipe is brazed, its end should be belled out to fill the chamfer shown at upper end of each sleeve for copper pipe, by Diagram 1. This application is shown by Fig. 1. Under no circumstances should a sleeve be counterbored for a portion of its length and a copper pipe fitted into this short counterbore and brazed. This arrangement to be avoided is shown by Fig. 2. Another practice to be avoided is that of brazing a short ring on the end of a copper pipe instead of applying a proper sleeve. Such a ring can not be more than about ⅜-in. long without taking up too much of the thread in the nut. A surface ⅜-in. in length is too short to braze safely. This unsafe arrangement is shown by Fig. 3.

A collar 1¼ in. long is considered of ample length with either a mechanical joint or brazing. It is not probable that a longer surface will be thoroughly brazed throughout its entire surface. When this length of surface is properly brazed it is considered sufficient and if the sleeve is made longer without brazing the whole surface, the added length is of no benefit. All of the sleeves for use with copper pipes are shown by Diagram 1 as 1¼ in. in length.

The sleeves for use with iron pipes as shown by Diagram 1 are considered of reasonable thickness. It will be observed that the inside diameter of the sleeve is shown by the sketches to be smaller in many cases than the inside diameter of the pipe. This is done to provide ample thickness in the sleeve.

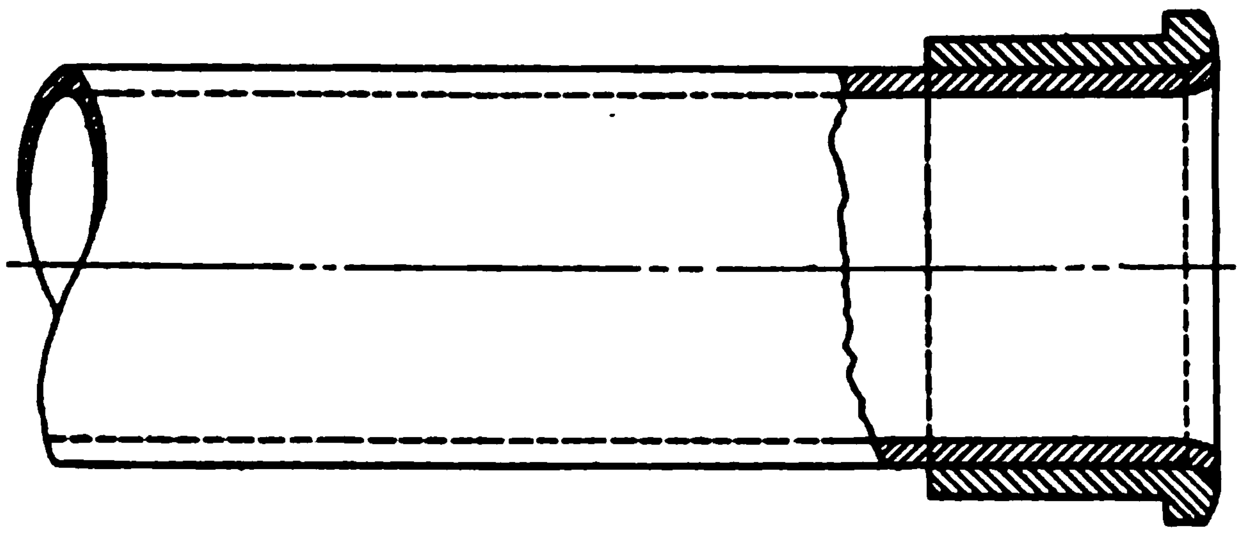


Fig. 1 Proper application of sleeve to copper pipe with brazed joint.

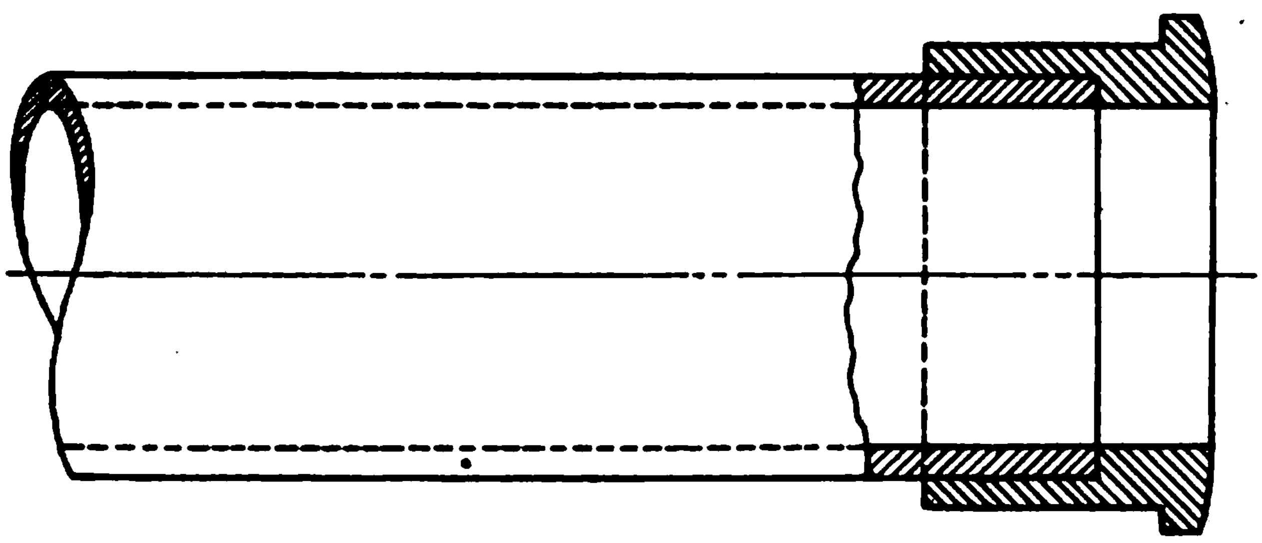


Fig 2. Improper application of sleeve to copper pipe. This should be avoided

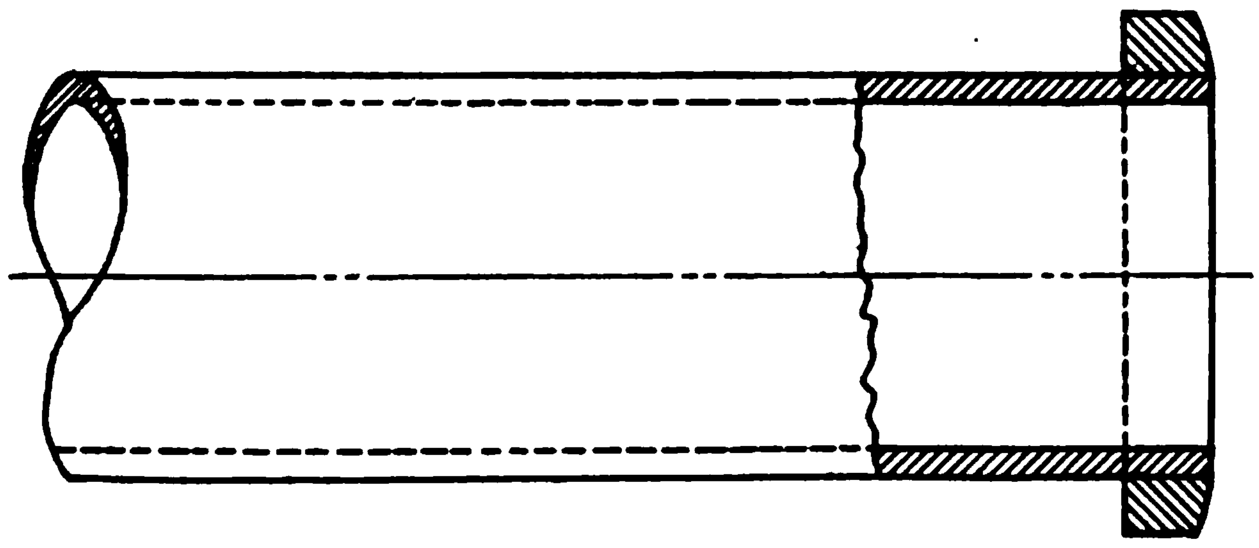


Fig. 3. Short rings as here shown should not be used.

DIMENSIONS OF FLANGE COUPLINGS.

Where flange couplings are used the threads should conform to the shape, dimensions and pitch shown by Table 1 and the sleeves used with flange couplings should conform to the dimensions shown by Diagram 1 for the respective sizes of pipe. The dimensions of flange couplings of the different manufacturers have been compared and considered with the dimensions of connections submitted by the various railroads. This investigation has led to the proposed standard form and dimensions of flange couplings shown by Table 2.

To provide against any possible weakness due to blow holes, porous metal or other defects in cast steel, it is recommended to make the flanges of forged steel. It is believed that the little additional cost of drop forgings will be justified.

The paper presented by Mr. Foster at the last convention included, among other illustrations, a set of sketches and tables giving the dimensions of flanges made by the different manufacturers and showing methods of using both mechanical and brazed joints with flange couplings. These are shown by Plate VI, opposite to page 66 of the 1914 Proceedings. For further illustration of the mechanical joint, Fig. 4 shows typical examples of equipment now in service on a few roads. Equipment of dimensions shown by Table 2 are applicable with pipe secured by beading over end or by brazing. Hole through flange is of same diameter as hole through coupling nut, and, consequently, fits the same sleeve for a given size of pipe.

OPINIONS ON BRAZED AND MECHANICAL JOINTS.

The replies made by the roads to the committee's questions, as well as the prints submitted, indicate a very general use of the brass spanner nut. The most common practice is to braze a brass sleeve to copper pipe and to screw a brass sleeve to the iron pipe. Of the thirty-six roads communicating with the committee, thirty-one report using brazed joints only and five report using some joints that are not brazed. Among the thirty-one are two roads which chamfer the end of the sleeve and expand or bell the end of pipe into the chamfer. This supplements the brazing and the roads using it report this practice as quite satisfactory.

The five roads which report joints without brazing, extend end of pipe through nipple and bead over the end of pipe so that it forms a ball joint. Two of the roads submit illustrations showing the pipe merely rolled into nipple in addition to beading over. One road, as an additional precaution, expands the pipe into a single, narrow groove around the inner circumference of the nipple. The other two expand the pipe into three narrow grooves.

As to comparison between the brazed and mechanical joints, most of the roads are noncommittal, having had no experience with the mechanical joint. Several of these roads state very definitely that the brazed joints are thoroughly satisfactory and have led to no complaint.

TABLE 2
PROPOSED STANDARD FORM AND DIMENSIONS
FOR INJECTOR FLANGE COUPLINGS.

Shape of threads and pitch to be according to Table I

Material in flange — Forged Steel

Dimension F of flange coupling is same as diameter of hole through coupling nut for corresponding size of pipe, shown by diagram I.

Sleeves secured by beading over end of pipe are of the same dimensions as those secured by brazing. Equipment of above dimensions are, therefore, applicable with either method of securing pipe.

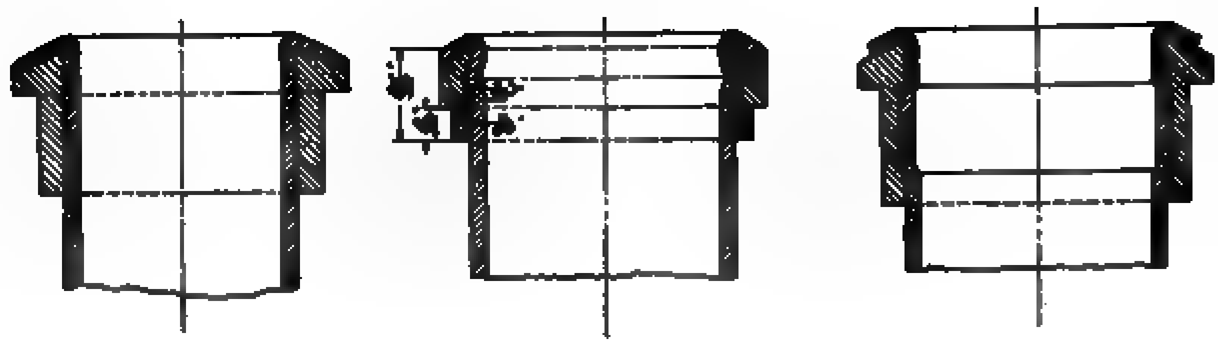


Fig. 4. Typical Examples of Mechanical Joints in use on some Railroads.

One road just beginning the use of the mechanical joint has adopted it under the belief that it is the "safest which can be depended upon in shop practice." The road using the mechanical joint when nipples are thin states that it compares favorably with brazing. Another road reports the mechanical joint to be "more uniform than brazing."

With regard to recommending mechanical joints as standard, nine roads definitely vote "no" and two "yes."

With regard to mechanical joint being more convenient at outlying points than brazing, eight roads vote "no" and two "yes." One road replies "think so," indicating a belief that the mechanical joint is more convenient but that it has not yet been demonstrated. Another road writes: "not with copper pipe."

Concerning both these questions, many of the roads report use of brazed joints only or state that the brazed joints are meeting requirements. One road writes the mechanical joint is "convenient enough, but not as satisfactory." Another road writes "such joints could easily be made standard, although there would be loss of pipe when renewing sleeve or nut. Have found no objections to either mechanical joints or brazing for outlying points."

COMMENTS ON FLANGE CONNECTION AS COMPARED WITH SPANNER NUT.

Twenty-four roads reply definitely "no" to the question as to whether the flange connection is favored in preference to the spanner nut. One road reporting the use of spanner nuts makes the comment that "the flange connection seems to have the advantage which makes it seem more desirable than the spanner nut." A road using spanner nuts in connection with lifting injectors and flange connection with non-lifting injectors, reports both as satisfactory where used. One road comments on the spanner nut as easier to get at. Another says flange connection is too cumbersome. One road comments emphatically in favor of the flange connection. Another commends it, especially for new work. Another opinion is expressed as follows: "We prefer the spanner nut. When drawn down it gives an even distribution of bearing weight. Flange connection may be drawn down tighter on one bolt than the others, resulting in broken joint after short service." Still another comment is worthy of quoting in full: "Have never used flange connection. While it is possible the flange connection would not be as subject to leaks as a coupling nut and nipple, these joints are broken so many times that the ease with which the coupling nut connection can be taken apart we believe outweighs any advantage to be gained with the flange."

MATERIAL IN COUPLING NUTS AND SLEEVES.

Spanner nuts and sleeves are commonly made of brass. This is rather a general term and the material is a grade of bronze or a tough metal of comparatively high tensile strength. A number of compositions, some

more or less alike, were reported by various railroads. The following composition impresses the committee as a satisfactory mixture:

Copper	84 to 86 per cent.
Zinc	4 to 6 per cent.
Tin	4 to 6 per cent.
Lead	4 to 6 per cent.

REINFORCED SPANNER NUTS.

Several manufacturers have reinforced brass, or bronze, spanner nuts with steel bands around them. The bands not only provide against the nut stretching if improperly tightened, but also receive the punishment if a careless workman attempts to tighten the nut with a set or chisel.

SPELTER.

In brazing, the usual practice of spelter with borax flux is commonly followed. Various roads report spelter of different manufacture. Eight roads report a mixture of fifty per cent copper and fifty per cent zinc. Two report a mixture of eighty per cent copper and twenty per cent zinc. A mixture of fifty per cent copper and fifty per cent zinc seems to be the most commonly used.

BRAZING.

The use of an open fire with charcoal or coke as fuel is common practice in brazing. The open fire allows a proper observation of the work and provides an opportunity to see that the spelter reaches the joint properly. Hard coal, oil, gasoline and gas are used by some roads as fuel for brazing, furnaces being used in some cases and open fire in others. The roads generally report the same method of brazing at outlying points as at the small shop, except where certain conveniences are justified at one or the other by local conditions.

BRAZING BY OXY-ACETYLENE PROCESS.

As a shop of one road reported doing all brazing by the oxy-acetylene process, more definite information as to results obtained was requested by the committee. In making this request it was mentioned that objection had been raised by one road that the oxy-acetylene has a tendency to oxidize the zinc in the brass, and would, therefore, cause a porous joint. The reply is quoted, in part, as follows: "Since adopting this practice we have had very good success with it; in fact, have not had one joint leak where it was brazed, and we do not find that it oxidizes the zinc in the brass or causes joint to become porous. We find it saves a great deal of time. In fact, we can braze pipes by this method in five to eight minutes which would otherwise take thirty minutes with charcoal fire. In the eight months that we have been using this process we have not had one failure."

MATERIAL IN INJECTOR PIPES.

The general practice is to use copper in steam pipes for both lifting and non-lifting injectors and to use iron pipes for water, delivery and overflow.

APPLICATION OF INJECTOR EQUIPMENT.

Leaks at the various couplings and connections result primarily from vibration. The water feed or suction pipe in particular should be thoroughly clamped. Injectors should be properly bolted to stiff brackets. Steam pipes should be bent with easy curves and the bends should not be abrupt. The actual length of pipe should be much greater than that of a straight line between terminal connections. The bends required to avoid obstructions, to adhere to the contour of the boiler and to meet the fountain and injector connections often provide sufficient bends for expansion. It is necessary that due allowance be made for expansion and contraction and it is the opinion of the committee that a bend approaching a reverse curve meets requirements most satisfactorily. The bends in the pipe should be on a radius of at least from 10 in. to 14 in.

LEVER STARTING VALVE SUPPORT.

It is recommended that the lever starting valve of non-lifting injectors be clamped to the boiler and that the valve body be designed with a lug to facilitate this. To support valves not already provided with such lugs, a rigid clamp should be secured to the steam pipe immediately below the starting valve and one just above the starting valve.

USE OF STANDARDS.

In concluding its report the committee respectfully directs the attention of the individual members of the Association to the number of ballots actually cast, in proportion to the number of members, when voting on recommended practices and adopted standards. If the standards proposed by this committee are to be adopted, the votes deciding this should be cast with the idea of applying future injectors and couplings accordingly. If the question is voted on in the affirmative without intending to use the standards, it will be better to reject them.

Respectfully submitted,

M. H. HAIG, Chairman,
T. F. BARTON,
S. B. ANDREWS,
W. H. WINTERROWD,
B. F. KUHN,

Committee.

Mr. M. H. Haig: The preparation of a set of standards naturally incurs more or less inconvenience and expense. It was, therefore, the effort of the committee to decide upon standards which would result in the least amount of expense, hardship or inconvenience upon the railroads or the manufacturers.

The standards which are presented are selected from those, or rather from dimensions of parts, which are in use and which, from the information provided by the railroads, seem to be in the most general use.

Quite a number of roads reported ten threads per inch as a standard. A number of other roads showed that they had a large number of injector parts with that thread. There are different shapes and forms of threads, and it was believed that a modified thread, such as shown in this paper, would interchange with those already in service and would result thereby in the least expense.

The proportions of the standard forms and dimensions of thread for injector couplings are shown by Table I. Diagram I shows the proportions of standard dimensions of injector couplings, nuts and sleeves.

It will be ovserved that the metal is thicker in the nuts than according to general practice. The nuts are sometimes subject to abuse, and it is therefore suggested to make them thick, to get ample strength, and to leave them rough, to get the benefit of the skin of the metal.

There are a number of patented nuts of reinforced form. There is no reason why such nuts can not be used, if the threads agree with the standards, and if the size of the opening in the back agrees with the standard.

The manufacturers were invited to coöperate with the committee and were urged to be present at all meetings. Representatives of some manufacturers attended all the meetings. I think, Mr. Chairman, that if the paper has been read and if the diagrams have been looked over, that nothing need further be said by the chairman of the committee, unless some discussion arises.

Before taking my seat, I would make a motion, if a motion is necessary, that the privilege of the floor be extended to the rep-

resentatives of the injector manufacturers and also the representatives of the Federal Bureau of Boiler Inspection.

THE CHAIRMAN: Gentlemen, you have heard the suggestion of the chairman of the committee. If there are no objections, that will be considered the sense of this meeting. There being no objection, the gentlemen referred to have the privilege of the floor.

MR. STRICKLAND L. KNEASS (Wm. Sellers & Co., Incorporated): Mr. Chairman, it is difficult to discuss an important paper of this kind, which really depends upon details of construction and proportion, so that it will be at all clear to an audience, unless there are diagrams which show the points to be raised.

During the past year I acted as chairman of the Committee of Manufacturers on the general subject of coupling nuts, flanges, connections and threads for injectors, valves, and various attachments. That subject was considered from the same point of view as by this committee, with the purpose of reducing the number of threads to the minimum, and at the same time obtain the strongest form which would be of service.

This committee reported in detail to the Master Mechanics' committee and submitted a complete report under date of January 18, 1915, but to my regret certain of its recommendations were not accepted. My discussion is based upon the report of the Manufacturers' Committee.

The principal point at issue, to which I wish to call your attention, is the pitch of thread.

Mr. Haig's committee advocates a uniform pitch of ten threads per inch. The Manufacturers' Committee thinks it preferable to increase the pitch with the diameter of the nut, within certain limits, on account of the difficulty of properly fitting fine threads and the danger of crossing the threads when the nuts are partially worn. This is especially true of the larger nuts. For these reasons the Manufacturers' Committee prefers, recommends and is prepared to supply nuts and branches threaded eight per inch for all diameters, three inches and above, in accordance with standard nuts in use on railroads since 1876.

I have two tables which I would like to place on record. Table I shows the nuts now in use, and there are comparatively few. From 1¼ to 3 in. iron pipe, there are only nine different sizes in general use with locomotive injectors and valves in the United States.

The Manufacturers' Committee decided that many nuts now in use are of inferior design. They are ready to supply nuts to interchange with all those now in use, but with the hope that in time the nuts of the finer-threaded pitch will be gradually eliminated and replaced with nuts of coarser pitch which are already standard.

The manufacturers therefore recommended the general but gradual adoption of a standard (shown in Table II) which is used by many of the largest railroads in the country. The pitches are ten per inch for the smaller nuts 2⅛ and 2⅜ nominal diameter; eight per inch for 3 in. nominal diameter and above. There is no intention whatever to introduce a new standard, but to elim-

TABLE I.

PRESENT THREADS—INJECTORS, VALVES AND HOSE CONNECTIONS.

Nominal Size M/M	Nominal Size Inches	Thd's per Inch	Iron Pipe Size	Symbol	Standard of	Made Also By		
25	1	16	3/8	LL	Sellers			
30	1 3/16	12	1/2	KK	Sellers			
35	1 3/8	11½	3/4	JJ	Nathan	Sellers		
36[5]	1 7/16	12	3/4	HH	Sellers			
44	1 3/4	12	1	CC	Sellers			
50[4]	2	10	1¼	A	Nathan	Sellers	Hancock	Ohio
60	2 3/8	10	1½	E	Sellers	Hancock	Nathan	Ohio
71[8]	2 13/16	10	1½	J	Nathan	Sellers	Hancock	Ohio
73	2 7/8	14	2	K	Hancock	Sellers		
76[5]	3	8	2	N	Sellers	Hancock	Nathan	Ohio
77	3	10	2	M	Nathan	Sellers	Hancock	Ohio
88	3½*	8	2½	P	Sellers	Nathan	Hancock	Ohio
89	3½	10	2½	R	Hancock	Sellers		
95	3¾*	8	3	S	Hancock	Sellers	Nathan	Ohio
100[6]	3 15/16	10	3	T	Nathan	Sellers	Hancock	Ohio
102	4	10	3	V	Hancock			
102	4*	8	3	X	Sellers			
104	4⅛	8	3	Y	Sellers	Nathan		Ohio
114	4½*	8	3½	Z	Hancock	Sellers	Nathan	Ohio

*Standard Hose Nut Sizes.

TABLE II.

Proposed Standard for Threaded Nuts and Unions.

Size of Pipe		Nominal Size		Symbol	Dimensions (in inches) Male and Female Thread.			
Iron Inside	Copper Outside	Inches	Thd's per Inch		A	B	C	D
⅜	½	1	16	LL	.99606	.98425	.88976	.90157
½	¾	1 3/16	12	KK	1.18897	1 16929	1 03543	1 05511
¾	1	1 7/16	12	HH	1.44881	1.42913	1.29921	1 31889
1	1¼	1¾	12	BB	1 75590	1.73622	1 60630	1 62598
1¼	1½	2⅛	10	[illegible]	2 12598	2 10236	1 94881	1.97244
1½	1¾	2⅜	10	E	2 37401	2 35228	2 20078	2.22244
2	2¼	3	8	N	3 02755	3 00000	2 81102	2 83858
2½	2¾	3½*	8	P	3 47244	3 44487	3 25590	3.28345
		3¾*	8	S	3 77275	3 74520	3 55622*	3 58378
3	3¼	4*	8	X	4.00655	3 97900	3.79002	3.81758
3½	3¾	4½*	8	Z	4 51355	4 49600	4 30702	4 33538

*Standard Hose Nut Sizes.

inate those nuts which are less serviceable than those of coarser pitch.

Mr. Haig's committee accepted the recommendation of the Manufacturers' Committee covering the special shape of threads (also shown in Table II). The writer brought this form of thread to the attention of the Master Mechanics' Association in the discussion of Mr. Foster's paper last June. It was designed by the writer in 1890, and has been used ever since. It closely resembles the U. S. standard, but instead of having a flat bottom, it has a sharp bottom and a flat top. It is a thread that does not burr easily, and is easy to machine. The open triangle at the

root of the thread gives a space for dirt or chips to collect, or any slight deposits which may be on the thread.

The Manufacturers' Committee also thinks that Mr. Haig has made his coupling nuts unnecessarily heavy. There is sufficient metal in the present design of nut. If cast with the mixture given in Mr. Haig's paper, an eight-per-inch nut for 2½-in. iron pipe will stand a strain of 30000 to 35000 lb. I placed a standard nut in a testing machine and it finally yielded at the collar at 35300 lb. It would seem therefore unnecessary to increase the thickness or width, especially as the rising cost of copper, tin and zinc would add materially to the expense. The manufacturers' design has a large safety factor if made of good material. Mr. Haig has referred to the advantage of reinforcing the nut with a steel band. This eliminates the necessity for an increase in size, and it will stand the destructive action of the standard spanner, as he suggests.

Another point at issue is the radius of the ball joint as designed by the committee. The ball face is much flatter and agrees with no present standard, and present standards are proving entirely satisfactory. The general practice of the foreign railroads, especially the English and French, is to use more conical joints than we do.

As to brazing unions, I would say that the form of brazing ring has been redesigned by the Manufacturers' Committee. Tests of the brazed union show that the cause of failure is largely due to lack of penetration of the brazing material between the copper pipe and the ring. For that reason they recommend a counter bore of the ring to a point within its head, and the beveling of lower face to permit slight flanging of the copper pipe toward the ball joint. The counter bore leaves a space of about 1-64 in. on each side to permit the brazing material to run down to the collar of the brazing ring, adding materially to the strength of the joint. The breaking strength of the joint of a 2¼-in. copper pipe runs from 17000 to 22000 lb.

The Committee of Manufacturers desires to inform the Association that a standard of diameters and pitches of threads of injector valve branches and coupling nuts, of unions and their radii, has been in force for many years. Table I includes the

standard of nuts shown in Table II, established in 1860, and those introduced later. It covers the equipment of about 98 per cent of the locomotives of the United States. It is conceded, however, confusion, inconvenience and added expense to the railroads are caused by the unwarranted variety of pitch for the same diameters.

The committee recommends to railroads, locomotive builders and all manufacturers the gradual elimination of the fine-thread nuts of large diameter and the adoption of the design of nuts shown in Table II. This table (the suggested standard) has been carefully worked out with decimal dimensions for the root and the flat top, for the male and female threads. It is accepted by and in use upon many of the large railroad systems.

THE CHAIRMAN: This is a rather technical subject. Mr. Haig, how would it be possible to handle this matter? Would your committee like to have another year with the Manufacturers' Association to present something that we could go on as recommended practice?

MR. HAIG: Mr. Chairman, Mr. Kneass' presenting his remarks as a representative of a manufacturers' committee was somewhat of a surprise to me, for the reason that I do not understand his statements to agree with those of individual representatives who have discussed this matter with me.

I think that the matter which Mr. Kneass presented to-day would have been presented to much better advantage at the meetings at which he was urged to be present.

The tables which he presents were thoroughly investigated and discussed by the railroad men, as well as by the representatives of manufacturers who attended the committee meetings, and it was agreed that the standards of 1861, or whatever his date was, would not be as satisfactory as those which the reports from the railroads indicated to be the more common to-day.

If, however, there is any question in the minds of the members at this convention as to whether the subject should be investigated further, it might be as well to put off the final report for another year; but I think such postponement would simply cause delay. If the recommendation of the committee is placed before

letter ballot, I think we could reach a conclusion and save some time in coming to a standard.

Mr. Thomson: I rather feel that we should put this matter off for another year. There does not seem to be any agreement, according to what has been said here to-day, and I rather feel that there would be a mistake made if we adopt the report, which I understand proposes ten threads per inch throughout. It does not seem to me mechanical, that, if ten threads per inch is right for a three-eighths pipe, it is also right for a 3-in. pipe. Of course, you can make the threaded parts heavy enough to prevent some of the trouble, but we have had a great deal of complaint concerning fine threads on large pipe. The pipe connections on certain classes of our engines are stretching and the threads crossing, causing continual leakage; and there is no reason in the world but that the threads are too fine and possibly the threaded parts a little light. It seems to me that there ought to be some division of the sizes, in order to get about two standards, say ten threads up to two inches, and eight threads above. The same number of threads for all sizes of pipe does not really seem to me mechanical. The committee has evidently arrived at this ten threads from the reports they received of what sizes were being used, but those reports evidently did not bring out what trouble they were having with these sizes. I think we ought first to get the design right, and then determine how we can make the change with the least expense in applying that design. We want the design right first, and then get to work on the cheapest way to make it standard. There is quite a divergence of opinion, and I am rather inclined to agree with the opposition report just given here, which recommends, as I understand, that the threads for the larger pipe be made heavier, and that two or three sizes or numbers per inch be used, instead of standardizing one size. I may not understand the committee's report, since I have not had a chance to study the detail of it, but if it is the idea that ten threads throughout be used, I would suggest, and make a motion to that effect, that this committee be continued and give us another report next year.

D. R. MacBain: I will second the motion, Mr. Chairman.

Motion put to vote and carried.

The Chairman: The next order is the report of the Committee on Subjects.

The Secretary presented the report.

REPORT OF COMMITTEE ON SUBJECTS.

To the Members:

The Committee on Subjects for the 1916 meeting of the Association submits the following report:

That the present standing committees be continued.

That the following subjects be assigned to special committees:

1. Equalization of long locomotives, so as to secure the most effective guiding from the trucks, both leading and trailing.

2. Tender Trucks. Best practice and type of tender truck for passenger locomotives. Has a swing truck any advantage over a rigid truck?

3. Reciprocating and Revolving Weights. Committee to report on possibilities of lightening.

4. Transmission of electric power from motors to driving wheels of electric locomotives. Committee to report on the progress in this direction.

5. Use of pyrometers on superheater locomotives.

6. Piston Valves, Rings and Bushings. Best material and sizes, with particular reference to superheated steam.

7. Metal pilot designs.

8. Modernizing existing locomotives, which can then remain in service for ten or fifteen years.

That the following subjects be assigned for Topical Discussion:

1. Advantages, if any, of compounding superheater locomotives.
2. Side bearings on tenders.
3. Tender Derailments: Causes and remedies.
4. Road Instruction for Enginemen and Firemen.
5. Cross-head design.

A. W. Gibbs, Chairman,
D. R. MacBain,
C. E. Fuller,
Committee.

The Secretary: Mr. Chairman, the Committee on Subjects has submitted eight recommendations for committee work next year, and five recommendations for topical discussions at this convention. The topical discussions have been disposed of in so

far as they can be, and I would make a motion that the report of the committee be received and each subject be referred to the incoming committees.

Motion seconded and carried.

The President resumed the chair.

THE PRESIDENT: The next order is the report of the Committee on Correspondence and Resolutions.

MR. MACBAIN: Mr. President, the Committee on Correspondence and Resolutions wishes to suggest that the Association extend to the President of this Association its thanks for the splendid manner in which he has conducted the affairs of this Association for the year in which he has presided; to members of this Association for their attendance and close attention to the subjects which were read and discussed; to the committees who brought in the papers for discussion; to the Supply Men's Association for the splendid display of railroad tools and other appurtenances which are on exhibition and which are all of such great value to the railroad companies; to the Hotel Men's Association for the splendid accommodations furnished us, and the close attention given to our welfare, and last, but not least, to Mr. Lane for the splendid auditorium which we now have in which to hold our meetings.

THE SECRETARY: I move that the suggestions of the committee be accepted and spread upon the minutes.

Motion seconded and carried.

THE SECRETARY: Mr. President, Mr. H. T. Bentley, S. M. P., C. & N. W. Ry., and Mr. A. R. Ayers, C. M. E., N. Y. C. R. R., were requested to open topical discussions on the subjects of Tender Derailments, Their Causes and Remedies, and Crossheads, respectively. We were not able to reach this part of our program during this convention. If there are no objections, I will ask Messrs. Bentley and Ayers to submit in writing what they had to say, and will incorporate it in the printed report of this convention.

TENDER DERAILMENTS, THEIR CAUSES AND REMEDIES.

By MR. H. T. BENTLEY, S. M. P., C. & N. W. Ry.

In 1909 the question of tender derailments was a live one, and at the convention of that year a committee, of which I was chairman, reported on this subject. No one appeared to know just what was the cause, the mechanical men saying it was due to track conditions, whereas the roadmasters blamed it on the tenders, but the middle-of-the-road man said it was a combination of conditions that brought about the trouble.

About that year, or perhaps in 1910, Mr. Walsh, then superintendent of motive power and machinery of the C. & O., had an idea that the location of side bearings had more to do with derailments than anything else, and exhibited a model, which proved, at least to my satisfaction, that with the side bearings too far out there was a tendency to press down through the bolsters upon the journals on one side when going around a curve, with a corresponding reduction in pressure on the other side, so that under favorable conditions the weight on the outside wheels would be reduced to such an extent that they would at times mount the rail and a derailment occur, this being more liable with a high, short tank than with long, low one, but by having the side bearings located well inside of rail line, whatever pressure came on them tended to force both wheels down to the rail.

On our return from the convention, instructions were issued to change the location of all side bearings from 52-in. centers to approximately 36 in. at front end and about 48 in. at rear end, with about ⅛ in. clearance on front and 3-16 in. on rear bearings, after which our trouble ceased, and the only derailments of tenders we now have are easily accounted for.

Tenders with side springs outside of rail are liable to derailment if insufficient clearance is provided in the pockets in which springs set. Short safety chains are also liable to cause trouble; so may a truck that is out of square.

One case that occurred recently was due to a truck-column bolt that had been put in from the bottom, projecting so far above the top arch bar that it struck the tender side frame and prevented truck from curving.

The tenders that were reported liable to derailment, account having no splash plates, high center of gravity, wheel base of trucks too short, offset drawbar between engine and tender, and the numerous other things that were given as causes, are still staying on the track under the same conditions that they formerly operated, except that the side bearings have been moved in or proper clearance has been provided in spring pockets, and to any one having trouble of this character we would say go and do as we did.

CROSSHEADS.

By MR. A. R. AYERS, C. M. E., N. Y. C. R. R.

The necessity for reducing the weight of reciprocating parts on modern locomotives has directed considerable attention to crosshead design.

The alligator type has been most generally used for a number of years, and with excellent results, but it is heavier than some other designs. The Laird crosshead, for example, can be made much lighter than the alligator type and can be used to good advantage where the piston speed is not too high, as the large amount of weight at the top of the Laird crosshead introduces a tendency to vertical bending of the piston rod at high speeds.

A saving of about 60 lb. in weight can be made in connection with outside valve gears by designing the parts so that the union link may be fastened to the crosshead directly in line with the wrist pin, instead of using an arm extending downward, as is commonly done. At the same time this avoids unbalancing the crosshead at high piston speeds due to the overhanging weight of the arm and attached parts. Where it is not feasible to eliminate the arm, some saving in weight can be made by casting it integral with the crosshead body.

Sufficient attention is not always given to the depth of the side flanges. Where these have been increased from 1 in. in depth to 1¾ in., noticeable benefit has been obtained in reducing the lateral wear.

The alligator-type crosshead can be reduced in weight by casting the wearing surfaces integral with the body, but this makes it necessary to close the guides or to remove the crosshead from the engine for relining to take up wear, either of which methods has disadvantages in connection with heavy engines.

Of the two best known methods of attaching piston rod to crosshead, the design using the key is most generally used and weighs less than the one using nuts. The use of piston-valve cylinders has made necessary very secure fastening of the piston rod. It is the practice with some designers to show the end of the rod butted against a shoulder on the crosshead, in addition to the taper fit. This is a difficult, if not impossible, condition to obtain in ordinary shop practice. The rod is very likely to be loose in the taper and bear altogether against the shoulder, or vice versa. More uniformly satisfactory results can be obtained by omitting the shoulder and relying entirely upon the taper fit in one direction and the key in the other.

A taper of ⅜ in. in diameter in 12 in. for the piston-rod fit has been found too small, as it allows the rod to be drawn into the crosshead. Three-fourths inch in 12 is sufficient to make a tight fit, but the fit can only be maintained, regardless of the taper, by having ample size of crosshead hub around the rod.

The wrist-pin key is quite generally applied at the large end of the pin and held in place with a dowel, but occasionally the dowel breaks off and the key loses out. Very good results have been obtained by using a square key without any dowel, applied at the small end of the pin and held in place by the wrist-pin collar. Incidentally it may be said that the same construction has been used for side-rod knuckle pins with excellent results, the keys being on the outside end of the pins where they may be examined readily.

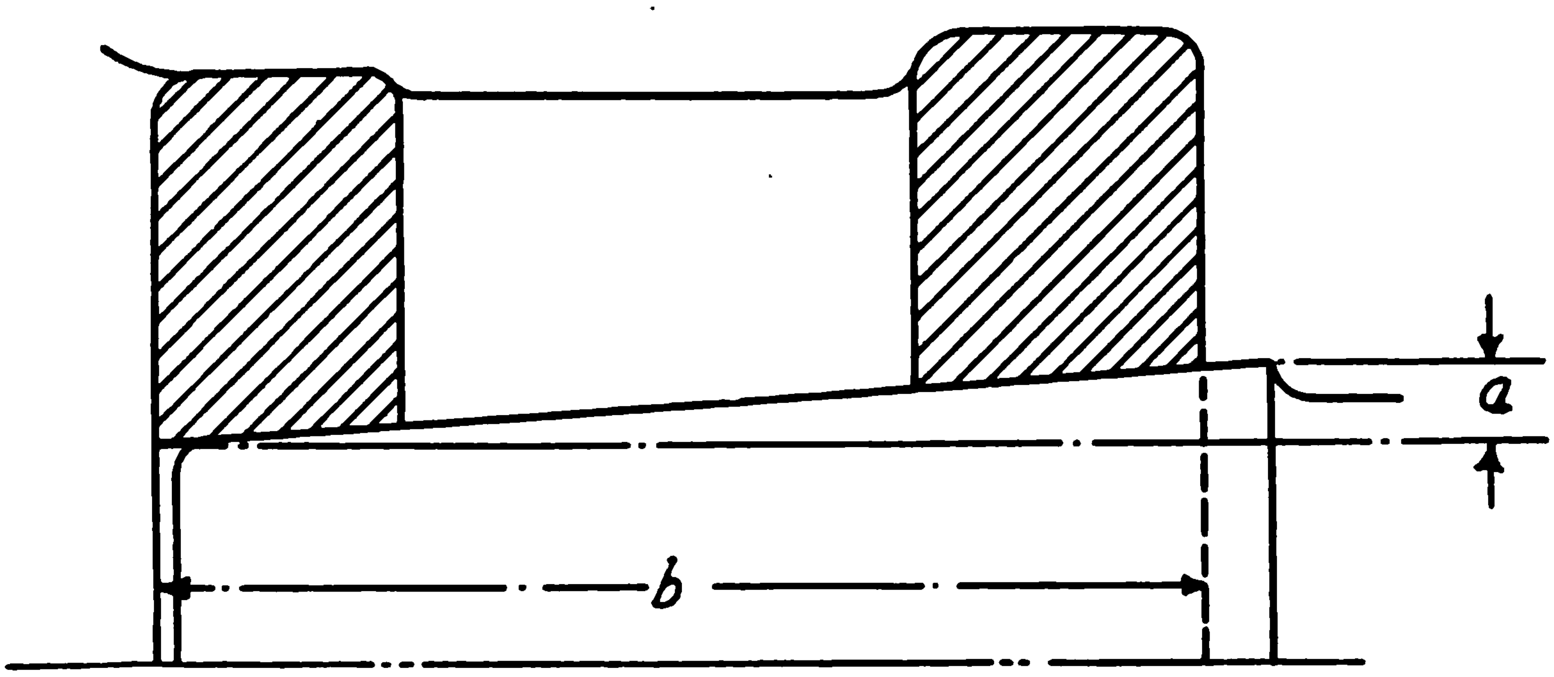
There have been several designs of crossheads brought out in very recent years embodying many of the features discussed above. One of the latest designs is the Philadelphia & Reading engine which was on exhibition at Atlantic City this year, in which the union link is fastened directly to the wrist pin and the crosshead shoes are made of aluminum cast solid onto the crosshead body and lined on the wearing surfaces. This design also employs a V-shaped guide, which takes care of lateral as well as vertical pressure.

Comparatively few calculations are used in designing crossheads. One builder uses 17,000 lb. shearing stress for vanadium-steel piston-rod keys up to 3½ in. diameter of rod and 14,000 lb. for 3¾ in. diameter and over; 4,800 lb. per square inch bearing pressure for wrist pins; and 100 lb. per sq. in. maximum bearing pressure on the shoes.

The size of hub around piston-rod fit may be obtained from the formula:

$$A = \frac{d^2 \times p}{C \times (.30 + t)}$$

In which A = Net effective area of cross-section through one side of crosshead through key slot, as indicated by shaded portion on sketch. (Sketch is attached.)



d = Diameter of cylinder.
p = Boiler pressure, pounds per square inch.
.30 = Assumed coefficient of friction between rod and crosshead.
t = Taper of one side of piston-rod fit in per cent.
C = A constant which varies according to the desired working stress per square inch.

At 6000 lb. per sq. in. working stress at boiler pressure C = 48,000, and this will give size of hub corresponding to designs which are known to be good from actual practice, but values of C may range from 42,000 to 62,000.

THE PRESIDENT: The next order is Unfinished Business. I have none. There is none on the Secretary's table.

THE PRESIDENT: Has anybody any unfinished business?

[No response.]

The next order of business is the Election of Officers. Will the Secretary please read the constitutional provisions relating to the election of officers.

The Secretary read the provisions of the constitution relating to the election of officers.

THE SECRETARY: The President has appointed as counting tellers Mr. G. W. Wildin, Mr. S. G. Thomson and Mr. D. R. MacBain, and for collecting tellers Mr. W. E. Dunham, Mr. M. H. Haig and Mr. William H. Flynn.

I might say that the present officers of the Association are as follows:

[Reads list.]

THE PRESIDENT: Gentlemen, prepare your ballots for President. The collecting tellers will collect the ballots, which will be counted by the counting tellers, and when the count is made the tellers will report the result.

Have all who desire to do so voted for President? If so, the ballot for President is closed.

Please give attention to the tellers' report of the balloting for President.

MR. WILDIN: Mr. President, the total number of votes cast is 62, of which E. W. Pratt received 61 and F. F. Gaines 1.

THE PRESIDENT: Mr. Pratt having received the majority of the votes cast, I declare him elected President of this Association for the ensuing year or until his successor is elected and installed in office.

Please prepare your ballots for First Vice-President.

Have you all voted for First Vice-President? If so, I declare the balloting closed.

Please prepare the ballot for the Second Vice-President

We will now hear the report of the tellers on the ballot for First Vice-President.

Mr. Wildin: Mr. President, the total number of ballots cast for First Vice-President is 73. Of this number William Schlafge received 70, E. W. Pratt 2 and F. H. Clark 1.

The President: Mr. Schlafge having received a majority of the votes cast for First Vice-President, I declare him elected as First Vice-President for the ensuing year, or until his successor is installed in office.

Have all voted for the office of Second Vice-President who desire to do so? If so, I declare the balloting closed.

While the tellers are counting the ballots for the Second Vice-President, will you please prepare your ballots for the office of Third Vice-President.

Gentlemen, give attention to the report of the tellers on the office of Second Vice-President.

Mr. Wildin: The total number of votes cast for the office of Second Vice-President is 79. Of this number F. H. Clark received 73, J. F. DeVoy 1 and C. H. Hogan 5.

The President: Mr. Clark having received a majority of the votes cast for Second Vice-President, I declare him elected as Second Vice-President for the ensuing year, or until his successor is installed in office.

Have all voted for the office of Third Vice-President who desire to do so? If so, I declare the balloting closed.

Please give your attention to the report of the tellers on the ballot for the office of Third Vice-President.

Mr. Wildin: The total number of votes cast for the office of Third Vice-President is 80. Of this number J. F. DeVoy received 19, C. H. Hogan 14, W. J. Tollerton 26, J. T. Wallis 5, C. F. Giles 4, John Purcell 6, W. H. Flynn 1, J. R. Gould 1, R. E. Smith 2, M. D. Franey 1 and B. P. Flory 1.

The President: A majority of the votes cast not having been for any one of the candidates, another ballot will be taken for the office of Third Vice-President.

Mr. Giles: I move that the balloting be confined to the three candidates who received the highest number of votes on the first ballot.

Motion seconded and carried.

The President: Have all voted for Third Vice-President who desire to do so? If so, the balloting will be closed.

Gentlemen, give attention to the report of the tellers on the office of Third Vice-President.

Mr. Wildin: In the second ballot for the office of Third Vice-President 85 votes were cast, of which W. J. Tollerton received 39, J. F. DeVoy 23 and C. H. Hogan 23.

The President: Gentlemen, there being no election this time, will you kindly prepare your ballots again for the office of Third Vice-President?

Have all voted for the office of Third Vice-President who desire to do so? If so, I declare the balloting closed.

Gentlemen, give attention to the report of the tellers on the office of Third Vice-President.

Mr. Wildin: On the third ballot for Third Vice-President 85 votes were cast. W. J. Tollerton received 43, C. H. Hogan 26 and J. F. DeVoy 14.

The President: Mr. Tollerton having received a majority of the votes cast for Third Vice-President, I declare him elected as Third Vice-President for the ensuing year, or until his successor is installed in office.

The members will now prepare their ballots for Treasurer.

Have all voted for the office of Treasurer who desire to do so? If so, I declare the balloting closed.

While the tellers are counting the votes for Treasurer, the members will please prepare their ballots for three members of the Executive Committee. The Executive Members who hold over for another year are Messrs. Purcell, Giles and Barnum. The retiring members are Messrs. Tollerton, DeVoy and Wallis. You have elected Mr. Tollerton as Third Vice-President. In voting this time, please vote for three members.

Mr. Giles: I move that the three candidates voted for for executive members who receive the highest number of votes be declared elected.

Motion seconded and carried.

The President: Have all voted for the office of Treasurer who desire to do so? If so, we will receive the report of the tellers.

Mr. Wildin: The total number of votes cast for Treasurer is 85. Mr. Angus Sinclair received 85 votes, nobody else being voted for.

The President: I declare Mr. Sinclair elected as the Treasurer of the Association for the ensuing year, or until his successor is installed in office.

Have all voted for Executive Members who desire to do so? If so, I declare the balloting closed.

Give your attention to the report of the tellers on the balloting for the Executive Members.

Mr. Wildin: For Executive Members there was a total number of votes cast of 177. Of this number C. H. Hogan received 41, J. F. DeVoy 39 and J. T. Wallis 19. The balance of the votes were scattered among twenty-seven other members.

The President: Messrs. Hogan, DeVoy and Wallis having received the highest number of votes cast, according to the motion which was passed, I declare them elected Executive Members for the ensuing year, or until their successors are elected and installed.

It now becomes my duty to turn over the gavel to my successor. In doing so I wish to thank the officers and members of the committees, and also all of the members of the Association for the very great assistance they have rendered to me during the past year.

Dr. Angus Sinclair: I believe it is my part to make a few remarks just at this moment. I have attended twenty-five conventions of the American Railway Master Mechanics' Association,

and have seen considerable diversity of management and not always harmony.

It is with very great pleasure that I desire to state that this meeting has been as well managed and as harmonious as any I have ever attended, and considerable credit is due to our retiring president, Mr. Gaines, for that condition; and I have very much pleasure in proposing a hearty vote of thanks to our retiring President, Mr. Gaines.

MR. MACBAIN: I have much pleasure in seconding that motion, Mr. President.

MR. WILDIN: I suggest that the motion be passed by a rising vote.

PRESIDENT-ELECT PRATT: With equal pleasure I put this motion: That the thanks of the Association be extended, through a rising vote, to the retiring President, Mr. Gaines.

The members rose, and the motion was unanimously passed.

EX-PRESIDENT GAINES: I thank you, gentlemen.

MR. W. E. SYMONS: Mr. President and Gentlemen: I request your attention for a moment. In all lines of human activity it is necessary to have leadership — the railway and engineering profession is no exception to that rule. The history of the American Railway Master Mechanics' Association, with the list of its leaders, is one of which we may all be proud. These men have made their mark in the world, and have assisted others in making their mark. Election to the highest office in this Association, the office to which is attached the responsibility of leadership of the Association, is usually by promotion, although the original selection to a subordinate office is usually made with considerable care, the members selecting those who are most able to assist the leader, and then assume leadership, and in the election of officers for the year just closed there was no exception to the rule.

The past year has been a very trying one to all railway companies by reason of questions of economy, valuation, government investigations, and various other matters with which railway officers have to deal, the combination resulting in placing heavy burdens on the heads of the motive power and other departments of

our railways, and upon officers of associations like this, who have to devise ways and means for effecting economies and solving other problems.

Our retiring President, Mr. Gaines, has been no exception to the rule in this respect; his activities have reflected alike honor and credit to himself and this Association. The Association has, under your wise leadership, passed through a successful year. The papers presented at this convention were of a high standard, the discussions orderly and dignified, your annual address was at once scholarly and masterful, marking as it does a distinct epoch in the history of this and its sister associations.

It has been customary on past occasions to present the retiring President with a jewel indicating the degree of approbation or esteem in which the members of the Association hold him as an executive officer, as a railway officer, as a man, and as a citizen, and on this particular occasion the pleasant duty of making the presentation of this jewel has fallen upon me.

Mr. Gaines, I take great pleasure in presenting to you this badge, or jewel, as the retiring President of this Association, and to say to you that it embodies in part our estimation of you as an executive officer, as an engineer, as a railway man, and our esteem and consideration for you as a citizen.

Your friends have noted with much concern and sympathy your physical indisposition, and I feel justified in saying, that if the high esteem and affectionate regard in which you are held by the members of this Association possessed curative properties, you would be at once restored to perfect health, and the Association would then be assured of the benefit of your wise counsels in years to come. [Applause.]

Ex-President Gaines: Mr. Symons and Gentlemen: I appreciate very highly the honor that has been conferred upon me, and I will ask Mr. MacBain to reply to Mr. Symons.

Mr. MacBain: Mr. Symons and Gentlemen: I think I can appreciate how Mr. Gaines feels, and I only wish to extend his heartfelt thanks to the officers and members of this Association for their many courtesies to him. I am sure that he particularly

appreciates the badge which has just been presented to him by Mr. Symons. [Applause.]

President Pratt: If there is no further business, a motion to adjourn is in order.

On motion, duly seconded, the meeting adjourned.

CIRCULAR RELATING TO LETTER BALLOT.

To the Members:

At the Convention of 1915 the following subjects were referred to letter ballot for adoption as a Standard or Recommended Practice.

Each subject is given a number for voting purposes. The page and sheet numbers referred to are shown in the 1914 Proceedings.

Each member is requested to vote "Yes" or "No" opposite the numeral on the accompanying voting slip, which corresponds with the numeral on the letter ballot circular, and mail it to the Secretary, 1112 Karpen Building, Chicago, Ill.

A vote "Yes" will mean the subject is to be adopted as a Standard or Recommended Practice, as the case may be, and a vote "No" will mean that it is not to be so adopted.

The votes will be counted September 19, 1915, and any votes received at the Secretary's office after that date will be excluded from the count.

All votes must be "Yes" or "No" to be counted in the result, as no qualified votes will be considered.

FROM THE COMMITTEE ON REVISION OF STANDARDS AND RECOMMENDED PRACTICE.

SPECIFICATIONS FOR STEEL AXLES FOR LOCOMOTIVE TENDERS. STANDARD.

Page 475.

The committee would recommend a revision and modification in form of the present specifications as follows:

To avoid repetition in printing, these specifications having been adopted, they are shown under the Standards on pages 487 to 490.

JOURNAL BOX AND DETAILS.

RECOMMENDED PRACTICE.

For journals 6 by 11 in.

Page 479, Sheets L, M and N.

The Committee on Revision of Standards and Recommended Practice recommends that these details be advanced from Recommended Practice to Standard.

2. Do you favor the above recommendation?

SPECIFICATIONS FOR BOILER AND FIRE-BOX STEEL. STANDARD.

Pages 490-492.

The Committee on Revision of Standards and Recommended Practice recommends a revision and modification of the present specifications as follows:

To avoid repetition in printing, these specifications having been adopted, they are shown under the Standards on pages 501 to 505.

SPECIFICATIONS FOR LOCOMOTIVE DRIVING AND ENGINE TRUCK AXLES, STANDARD (Pages 499 and 500) AND SPECIFICATIONS FOR LOCOMOTIVE FORGINGS, STANDARD (Pages 500 and 501).

The Committee on Revision of Standards and Recommended Practice recommends a revision and modification of the above specifications and combining them under one head.

To avoid repetition in printing, these specifications having been adopted, they are shown under the Standards on pages 511 to 515.

SPECIFICATIONS FOR LOCOMOTIVE CYLINDER CASTINGS, CYLINDER BUSHINGS, CYLINDER HEADS, STEAM CHESTS, VALVE BUSHINGS AND PACKING RINGS. STANDARD.

Pages 503 and 504.

The Committee on Revision of Standards and Recommended Practice recommends a revision and modification of the above specifications, as follows:

To avoid repetition in printing, these specifications having been adopted, they are shown under the Standards on pages 517 to 520.

SPECIFICATIONS FOR CAST-STEEL LOCOMOTIVE FRAMES. RECOMMENDED PRACTICE.

Page 504.

The Committee on Revision of Standards and Recommended Practice recommends a revision and modification of the above specifications, substituting for same the Specifications for Steel Castings for Locomotives, shown below:

To avoid repetition in printing, these specifications having been adopted, they are shown under the Standards on pages 520 to 524.

INSPECTION AND TESTING OF LOCOMOTIVE BOILERS. STANDARD.

Pages 531-538.

The Committee on Revision of Standards and Recommended Practice recommends that to conform to the latest revision of the federal regulations for the inspection and testing of locomotive boilers and their appurtenances, the following paragraphs should be revised as follows:

FACTOR OF SAFETY.

Section 2. The lowest factor of safety to be used for locomotive boilers constructed after January 1, 1912, shall be 4.

The lowest factor of safety to be used for locomotive boilers which were in service or under construction prior to January 1, 1912, shall be as follows:

Effective January 1, 1915, the lowest factor shall be 3, except that upon application this period may be extended not to exceed one year, if an investigation shows that conditions warrant it.

Effective January 1, 1916, the lowest factor shall be 3.25.
Effective January 1, 1917, the lowest factor shall be 3.5.
Effective January 1, 1919, the lowest factor shall be 3.75.
Effective January 1, 1921, the lowest factor shall be 4.

7. Do you favor the above recommendation?

Item 3. MAXIMUM ALLOWABLE STRESS ON STAYS AND BRACES.— For locomotives constructed after January 1, 1915, the maximum allowable stress per sq. in. of net cross sectional area on fire box and combustion chamber stays shall be 7500 lb. The maximum allowable stress per sq. in. of net cross sectional area on round, rectangular or gusset braces shall be 9000 lb.

For locomotives constructed prior to January 1, 1915, the maximum allowable stress on stays and braces shall meet the requirements of Rule No. 2, except that when a new fire box and wrapper sheet are applied to such locomotives, they shall be made to meet the requirements of Rule No. 3.

8. Do you favor the above recommendation?

STAY BOLT TESTING.

Item 24. Method of Testing Flexible Stay Bolts without Caps.— Flexible stay bolts which do not have caps shall be tested once each month, the same as rigid bolts.

Each time a hydrostatic test is applied, such stay bolt test shall be made while the boiler is under hydrostatic pressure not less than the allowed working pressure, and proper notation of such test made on Form No. 3.

Note.— To provide a proper service period between hydrostatic tests, removal of caps from flexible stay bolts and removal of flues for locomotives which are stored for an extended period, the time for performing such work on locomotives which are stored in good condition for one or more full calendar months may be extended without filing application, as follows:

Hydrostatic tests will be due after 12 months' service, provided such service is performed within 24 consecutive months.

Removal of caps from flexible stay bolts will be due after 18 months' service, provided such service is performed within 30 consecutive months.

Removal of flues will be due after three years' service, provided such service is performed within four consecutive years.

Time out of service must be properly covered by out-of-service reports and notation showing the months out of service on account of which the extension is claimed made on the back of inspection reports and cab cards.

No extension of time as provided above will be allowed for portions of a month.

If the locomotive is out of service when any of the above work is due, it need not be performed until just prior to the time the locomotive is returned to service.

9. Do you favor the above recommendation?

STEAM GAGES.

Item 29. Siphon.— Every gage shall have a siphon of ample capacity to prevent steam entering the gage. The pipe connection shall enter the boiler direct, and shall be maintained steam-tight between boiler and gage. The siphon pipe and its connections to the boiler must be cleaned each time the gage is tested.

10. Do you favor the above recommendation?

SAFETY VALVES.

Item 35. Setting of Safety Valves.— Safety valves shall be set to pop at pressures not exceeding 6 lb. above the working steam pressure. When setting safety valves, two steam gages shall be used, one of which must be so located that it will be in full view of the person engaged in setting such valves; and if the pressure indicated by the gages varies more than 3 lb. they shall be removed from the boiler, tested and corrected before the safety valves are set. Gages shall in all cases be tested immediately before the safety valves are set or any change made in the setting. When setting safety valves the water level in the boiler shall not be above the highest gage cock.

11. Do you favor the above recommendation?

FILING REPORTS.

Item 52. A copy of the monthly inspection report, Form No. 1, or annual inspection report, Form No. 3, properly filled out, shall be placed under glass in a conspicuous place in the cab of the locomotive, before the boiler inspected is put into service.

12. Do you favor the above recommendation?

Item 54. Specification Card.— A specification card, size 8 by 10½ in., Form No. 4, containing the results of the calculations made in determining the working pressure and other necessary data, shall be filed in the office of the chief inspector of locomotive boilers, for each locomotive boiler. A copy shall be filed in the office of the chief mechanical officer having charge of the locomotive. Every specification card shall be verified by the oath of the engineer making the calculations, and shall be approved by the chief mechanical officer. These specification cards shall be filed as promptly as thorough examination and accurate calculations will permit. Where accurate drawings of boilers are available, the data for specification card, Form No. 4, may be taken from the drawings, and such specification cards must be completed and forwarded prior to July 1, 1912. Where accurate drawings are not available, the required data must be obtained at the first opportunity when general repairs are made, or when flues are removed. Specification cards must be forwarded within one month after examination has been made, and all examinations must be completed and specification cards filed prior to July 1, 1913, flues being removed if necessary to enable the examination to be made before this date.

When any repairs or changes are made which affect the data shown on the specification card, a corrected card or an alteration report on an approved form, size 8 by 10½ in., properly certified to, giving details of such changes, shall be filed within 30 days from the date of their completion. This report should cover:

(a) Application of new barrel sheets or domes.

(b) Application of patches to barrels or domes of boilers, or to portion of wrapper sheet of crowbar which is not supported by stay bolts.

(c) Longitudinal seam reinforcements.

(d) Changes in size or number of braces, giving maximum stress.

(e) Initial application of superheaters, arch or water bar tubes, giving number and dimensions of tubes.

(f) Changes in number or capacity of safety valves.

Report of patches should be accompanied by a drawing or blue-print of the patch, showing its location in regard to the center line of boiler, giving all necessary dimensions and showing the nature and location of the defect. Patches previously applied should be reported the first time boiler is stripped to permit an examination.

13. Do you favor the above recommendation?

OPERATION OF BRAKES ON ENGINES AND TENDERS HANDLED DEAD IN TRAINS AND OFFERED IN INTERCHANGE.

RECOMMENDED PRACTICE.

The Committee on Revision of Standards and Recommended Practice recommends the following regulations covering the operation of brakes on engines and tenders handled dead in trains and offered in interchange:

1. All engines equipped with side rods must have them applied, when handled dead in trains, suitable washers, of wooden blocks clamped together with bolts, being used where necessary on main rod bearings to keep the side rods in place.

2. All engines and tenders hauled dead in trains must have the air brakes cut in and operative on drivers, trailers and on tender trucks.

3. Engines and tenders equipped with the Westinghouse ET, or New York LT brake, must have the safety valve on the distributing valve, or control valve, adjusted to not less than 25 lb. or more than 30 lb.

4. Engines and tenders equipped with the automatic and straight air combined must have the safety valve in brake cylinder pipe adjusted to not less than 25 lb. or more than 30 lb.

5. Engines equipped with Westinghouse ET, or New York LT brakes, or with straight air, must have positive stops applied to handles of automatic and independent valves to secure these handles in running position.

6. Engines and tenders equipped with high speed brake without the straight air, must have the high speed reducing valve set to reduce the brake cylinder pressure to not less than 25 lb. or more than 30 lb., or must have a safety valve applied to the brake cylinders or the brake cylinder pipe set to not less than 25 lb. or more than 30 lb.

7. Engines and tenders equipped with only the automatic brake must have a safety valve applied to the brake cylinders or the brake cylinder pipe set to not less than 25 lb. or more than 30 lb.

8. Engines fitted with power brakes other than air must be equipped with an air train line and connections.

9. Delivering line will be held responsible for flat spots on driving tires, trailer tires and tender truck wheels.

10. Owners shall be responsible for any special application of safety valves as required in Sections Nos. 3 to 8, inclusive.

14. Do you favor the above recommendation?

LOCOMOTIVE HEADLIGHTS.

At the 1914 Convention the Committee on Locomotive Headlights was continued in order that it could recommend for adoption by the Associations such standards as could be fixed from the data collected in the Columbus tests and as the present state of the art would permit. It was also instructed to recommend an accepted method of photometering headlights. The committee advises that:

There are a number of oil-lighted headlights on the market which will meet these requirements, and at least one which will give the maximum apparent beam candle-power recommended by the committee. There has also been developed during the last year at least three arrangements of reflectors with incandescent lamps which will meet these requirements.

In connection with the incandescent lamp headlight, the committee feels that the following standards should be adopted in order to direct the development of this type of headlight.

Voltage.

The voltage of the system should be fixed at 6 volts, for the following reasons:

1. This voltage will permit the use of standard 6-volt automobile lamps in the cab, markers, etc. Lamps in the 25-34 volt class, of the proper candle-power for this service, are not now made, and they will be difficult to develop.

2. This voltage will permit the use of incandescent lamps having the strongest possible filament of the most rugged construction. A complete line of 6 and 7 volt lamps has been manufactured for some years past for automobile service. No new sizes need be developed for locomotive service, except that the size and form of filament winding in the headlight lamp will have to be changed slightly to give the proper distribution of light.

3. This voltage will permit the use of a small storage battery on the locomotive, if so desired. Sufficient space is not now available on steam locomotives for 32-volt storage batteries.

4. This voltage can be obtained from a small turbo-generator as readily as any other voltage.

15. Do you favor the above recommendation?

Candle-power.

The Columbus tests show that an incandescent lamp of approximately 50 mean horizontal candle-power will give sufficient light to meet the recommended maximum requirement of 3000 apparent beam candle-power. Concentrated filament tungsten lamps are now regularly manufactured in candle-powers of 50, 100 and 160 at 6 and 7 volts, for headlight service. The two larger sizes are not deemed necessary by the committee. The specifications for the lamps the committee would recommend are:

For Use in the Headlight.

Fifty candle-power, 7 volt, G-20 clear bulb, Edison screw base (style 100), loop-back tungsten filament, multiple burning, headlight lamp.

(In case gas-filled lamps are used, the filament winding should be of such form and shape as to correspond closely with the form and shape of filament used in the lamp above described, and "gas-filled" must be specified when ordering.)

16. Do you favor the above recommendation?

For Use in Cab, Markers, Etc.

Six candle-power, 7 volt, G-10 clear bulb, double-contact bayonet candelabra base (style 1000), tungsten filament, multiple burning lamp.

17. Do you favor the above recommendation?

Socket.

Standard double-contact bayonet sockets are recommended for bayonet base lamps. Standard Edison screw sockets, equipped with Benjamin lamp grip, or equivalent, are recommended for use with the headlight lamp.

18. Do you favor the above recommendation?

Reflectors.

When metal reflectors are used, the minimum nominal diameter should not be less than 16 in. When parabolic glass reflectors or semaphore type lenses are used, the minimum nominal diameter should not be less than 12 in.

19. Do you favor the above recommendation?

Method of Photometering.

In the 1914 report the committee described in detail the apparatus and method used in the Columbus tests for photometering headlights, and on page 780 of the report it recommended that apparatus, conforming in all details to that used at Columbus, should be used in future investigations of this nature. This apparatus is somewhat cumbersome, however, and requires that a permanent location and considerable floor space be given to it. As shop space is usually very valuable, the committee is now of the opinion that a device of this kind will not find extensive use. A photometer table, constructed entirely of metal, has been developed along somewhat different lines, which, it is thought, will be more readily adaptable to railway service. This table is so designed that it may be readily handled or moved about, and may be set up in any location where sufficient floor space is available.

This table is shown in Exhibit "A." It consists of a platform (a) on which the headlight is mounted. This platform (a) is adjusted vertically by a screw (b) until the axis of the headlight corresponds with the point (c). The platform (a) and its adjusting-screw (b) are supported by a cradle (d), swinging in a vertical plane above a horizontal axis through the point (c), the whole being supported by a "U" frame (e) of steel tubing. The "U" frame (e) is in turn supported by and rotated horizontally on a metal base (f), provided with adjusting-screws for leveling. The platform (a) may be rotated about three degrees in either direction for finding the optical axis of the headlight. The scale (g) indicates the vertical angle and the scale (h) the horizontal angle through which the headlight is rotated. Both of these scales should be provided with verniers for accurate reading.

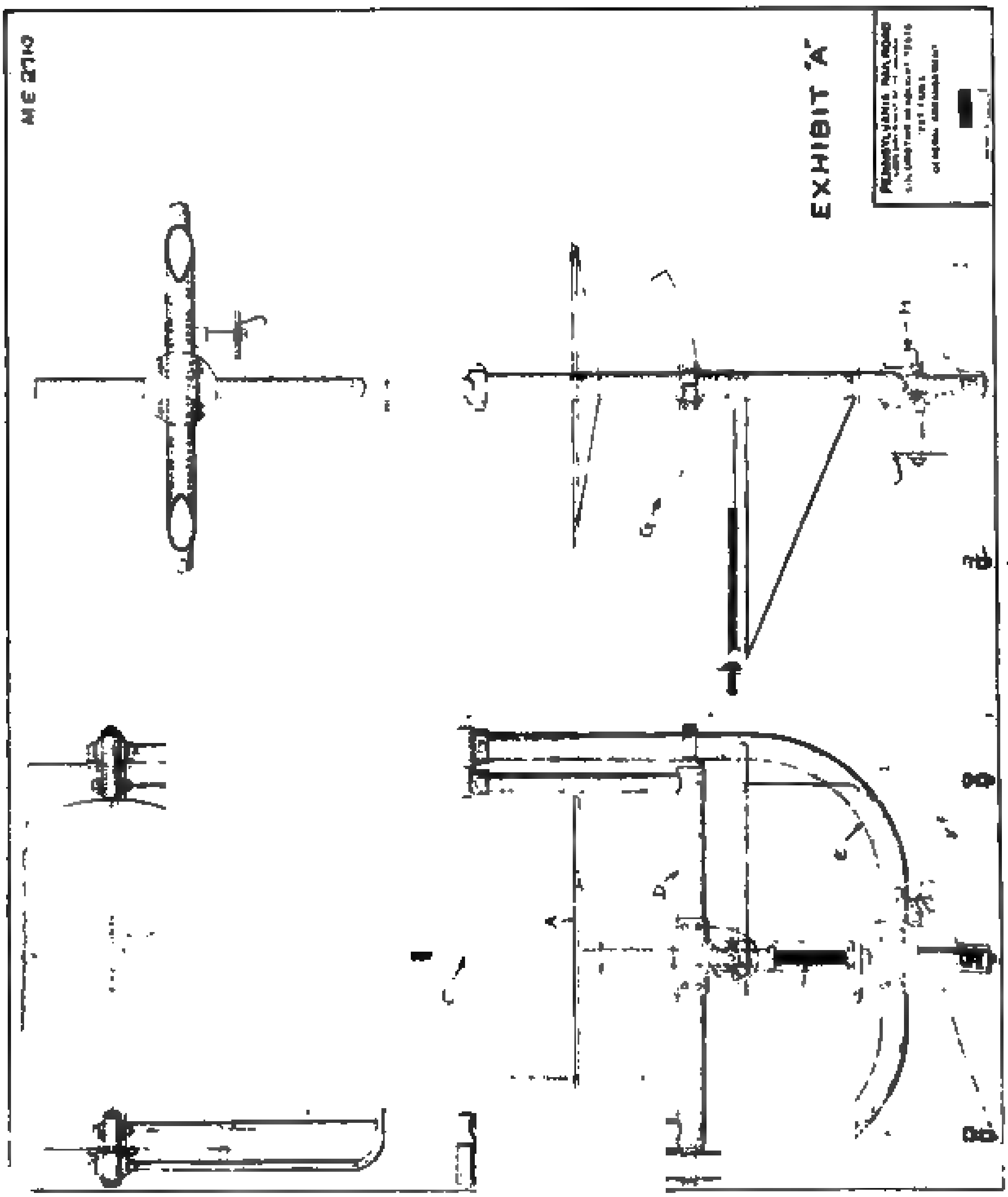


EXHIBIT 'A'
ME 2710

Space not less than 9 ft. wide by 9 ft. high and 30 ft. or more in length, depending upon the type of headlight to be photometered, must be provided and enclosed on all sides with light, tight material. Heavy canvas or oilcloth may be used for this purpose, and all interior surfaces must be painted dull black to avoid reflection. A candle-foot photometer is mounted at one end and the headlight table at the other end of the room. Between these a series of at least three canvas screens, painted dull black on both sides, should be attached to the ceiling, floors and walls. A hole approximately 1 ft. square should be cut in each screen on the axis of the headlight. The candle-foot photometer is mounted outside the photometer room, the milk-glass tube projecting through the end wall on the horizontal axis of the headlight.

The headlight should be set up at the following distances from the milk glass of the candle-foot photometer, depending upon the apparent beam candle-power of the headlight, as follows:

Apparent beam candle-power of headlight.	Distance of headlight from milk glass of candle-foot photometer.
1000 or less	15 ft.
1000 to 10,000	25 ft.
Above 10,000	50 ft.

The method of measuring this distance for parabolic reflectors, semaphore type of lenses, or inverted semaphore type of lenses is shown on Exhibit "B." Readings are taken by rotating the headlight, both vertically and horizontally, to throw on the milk glass of the candle-foot photometer those rays of light corresponding to the reading stations recommended in last year's report.

20. Do you favor the above recommendation?

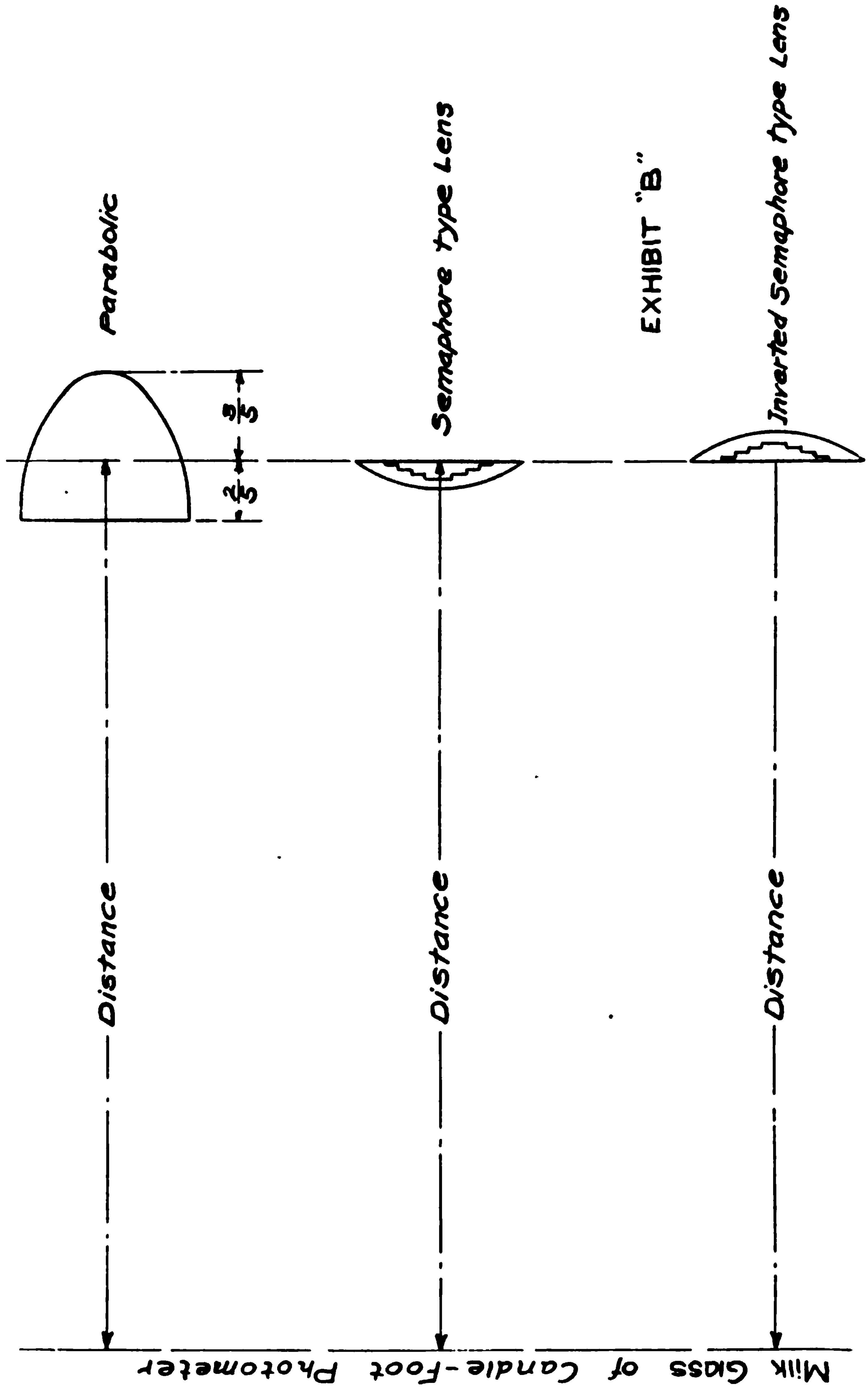
RULES FOR DETERMINING STRESSES IN LOCOMOTIVE BOILERS. RECOMMENDED PRACTICE.

The Committee on Design, Construction and Inspection of Locomotive Boilers submits the following rules for determining stresses in locomotive boilers:

I. LONGITUDINAL BARREL SEAMS AND PATCHES.

(a) In figuring net section of plate, use the actual diameter of rivet hole.

(b) In figuring rivet shear, use the actual diameter of the rivet after driven.


Parabolic
3/5
2/5
Semaphore type Lens
EXHIBIT "B"
Inverted Semaphore type Lens
Distance
Distance
Distance
Milk Glass of Candle-Foot Photometer

(c) In figuring stress in plate and shear in rivet, in case the barrel is not cylindrical where it joins the fire-box wrapper sheet, use the maximum diameter. Surfaces subject to bending action under pressure must be adequately braced to prevent bending stresses.

(d) When boiler shells are cut to apply steam domes or manholes, the amount of metal in flange and liner shall be equal in strength to the metal removed. When separate flange is used at base of dome, the entire net area of same shall be assumed as reinforcement. Where dome sheet is flanged direct to shell of boilers, a vertical distance of 2 in. from base of flange shall be assumed as reinforcement, using net area after rivet holes are deducted and using 28,500 lb. tens. str. per sq. in. as the ultimate strength, if dome sheet is welded vertically.

(e) Investigation of the strength of seams shall be along the lines of established engineering practices and formula for efficiency and strength and in accordance with paragraphs (a) and (b). Investigation of the strength of the seams by the usual engineering formula is a definite and determinable problem and there shall be no variations introduced in the usually accepted methods.

21. Do you favor the above recommendation?

2. LONGITUDINAL GUSSET BRACES AND FLAT SURFACES.

(a) In figuring stress in diagonal braces, allowance for the angularity of the brace shall be made.

(b) The sectional area of the brace and the strength of the attachment of the brace to the shell shall both be investigated and the lowest net strength shall be used.

(c) In determining the strength of gusset braces for supporting back head and tube sheets, use 100 per cent of rivet-bearing area, 80 per cent of rivet shear area and 90 per cent of gusset plate area, measured at right angles to the longest edge of gusset sheet, and of the three, select the minimum value.

(d) The calculation of stress in gusset braces shall cover both the section of the plate and strength of fasteners, and the lowest net strength shall be used.

(e) In figuring flat stayed surfaces, such as back heads, the boundary of the unsupported flat surface shall be located at a distance equal to outside radius of flange measured from inside of shell.

(f) No supporting value shall be assigned to the stiffness of flat plates on flat surfaces, as it is too small to be of material value.

(g) Reinforcing plates, such as back head liners, shall not be figured as having any staying or supporting value, but shall merely be considered

as mechanical reinforcements for various attachments, such as longitudinal stays, staybolts, etc.

(h) The distance beyond the outer row of flues on tube sheets, assumed to be self-supporting, shall be 2 in.

(i) In calculating the area to be stayed on front tube sheet, the area of the dry pipe hole shall be deducted.

(k) Tee irons or other members, when used subject to bending, shall be calculated without addition for strength of plate, and the stress in such beam and its abutments must not exceed 12,500 per sq. in. The spacing of the rivets over the supported surface shall be in conformity with that specified for staybolts. No allowance for value of such beams shall be made in calculating the total area of longitudinal braces that may be attached thereto.

(l) Where there are a number of diagonal stays supporting a flat surface, such as back head or front tube sheet, the proportion of area allotted to each brace shall be as follows:

Divide the entire net area to be stayed by the entire net area of braces. If it is felt that any individual brace is so segregated as to receive more than its fair proportion of the load, it shall be investigated separately as to the area which it supports.

(m) Patches when applied to the barrel of a boiler shall be designed with longitudinal and circumferential seams at least equal in strength to the main longitudinal and circumferential barrel seams. Patches may be applied to flat stayed surfaces with properly designed single-riveted seams without impairing the strength of the sheet.

22. Do you favor the above recommendation?

3. STAYBOLTS — RADIAL STAYS AND CROWN BAR BOLTS.

(a) In figuring the net area of staybolts to obtain the stress, the area of the tell-tale hole shall be deducted.

(b) When figuring area at root of thread, the area must depend upon the type of thread used, namely, United States, V or Whitworth threads, as the case may be.

(c) In determining the area for figuring stress on staybolts, the area of one staybolt shall be deducted from the rectangular area included between any four staybolts.

(d) In boilers with crown bars supported on fire-box side sheets and sling stays, the sling stays shall be considered as carrying the entire load.

23. Do you favor the above recommendation?

STANDARDIZATION OF TINWARE.

The committee on the above subject submitted designs for all classes of tinware in general use by the mechanical depart-

ments, and, on motion, they were ordered submitted to letter ballot for adoption as recommended practice.

To avoid repetition in printing, these specifications having been adopted, they are shown under the Standards on pages 619 to 641.

FUEL ECONOMY. RECOMMENDED PRACTICE.

The committee on the above subject proposed a manual of instructions for enginemen and firemen which embodies all the essential points of efficient locomotive operation, and at the same time is brief and free from technical data. On motion it was ordered submitted to letter ballot for adoption as recommended practice. It is as follows:

To avoid repetition in printing, these specifications having been adopted, they are shown under the Standards on pages 642 to 655.

FORGING SPECIFICATIONS.

The committee on the above subject under date of October 24, 1914, asked for criticism on certain proposed fiber stresses to be used in heat-treated carbon and alloy steel materials for forgings, but the replies received indicated that there was very little information available covering the results of the use of this material, and while the committee is not prepared to recommend final figures for proper stresses, it feels that the following table expresses the maximum fiber stresses which should be used in this grade of material in the design, and therefore presents it to the Association as information with the recommendation that it be submitted to letter ballot as recommended practice with the understanding that it will again be reviewed after more extended experience of the members before recommending it for advancement to standard. It is as follows:

	Heat-treated Carbon.		Alloy.	
	Tension and Compression.	Bending.	Tension and Compression.	Bending.
Main and parallel rods.	10 000	14 000	12 000	17 000
Piston rods...........	11 000	15 000	13 500	18 000
Driving axles.........	....	20 000	....	24 000
Crank pins..........	....	17 000	....	20 000

56. Do you favor the above recommendation?

QUENCHED AND TEMPERED CARBON STEEL AXLES, SHAFTS AND OTHER FORGINGS FOR LOCOMOTIVES AND CARS.

RECOMMENDED PRACTICE.

Pages 510 to 514.

The Committee on Forging Specifications recommends that the above specifications be modified in accordance with the following specifications for Quenched and Tempered Carbon Steel Forgings, in order to harmonize this specification with our alloy steel specifications, and also include a recommended proof test.

To avoid repetition in printing, these specifications having been adopted, they are shown under the Standards on pages 530 to 535.

SPECIFICATIONS FOR QUENCHED AND TEMPERED ALLOY STEEL FORGINGS.

RECOMMENDED PRACTICE.

Pages 505 to 510.

The Committee on Locomotive Forgings proposes a modification of the above specifications by adding a chrome-nickel alloy and also a recommended proof test.

To avoid repetition in printing, these specifications having been adopted, they are shown under the Standards on pages 524 to 530.

BOILER WASHING.

The Committee on Boiler Washing reported that, owing to the great difference in conditions under which locomotives are operated, the question of boiler washing could be treated only in a general way, and therefore submitted the following method as being good general practice. On motion it was ordered referred to letter ballot for adoption as recommended practice.

To avoid repetition in printing, these specifications having been adopted, they are shown under the Standards on pages 655 to 658.

JOS. W. TAYLOR,
Secretary.

LETTER BALLOT VOTING SLIP.

Write "Yes" or "No" opposite each subject noted below and return to the Secretary, 1112 Karpen Building, Chicago, Ill.

1. Specifications for steel axles.	....
2. Journal box and details.	....
3. Specifications for boiler and fire-box steel.	....
4. Specifications for forgings, etc.	....
5. Specifications for cylinder castings, etc.	....
6. Specifications for steel castings.	....
7. Factor of safety, boiler construction.	....
8. Allowable stress of stays and braces.	....
9. Stay-bolt testing.	....
10. Steam gages.	....
11. Safety valves.	....
12. Filing reports.	....
13. Specification cards.	....

14. Brakes on dead engines. ....
15. Voltage, locomotive headlights. ....
16. Candle-power, locomotive headlights. ....
17. Lamps for use in cab, markers, etc. ....
18. Lamp sockets. ....
19. Reflectors. ....
20. Method of photometering. ....
21. Stresses for boilers, rules for determining. ....
22. Longitudinal gusset braces, and flat surfaces. ....
23. Radial stays and crown-bar bolts. ....
24. Standardization of tinware. ....
25. Standardization of tinware. ....
26. Standardization of tinware. ....
27. Standardization of tinware. ....
28. Standardization of tinware. ....
29. Standardization of tinware. ....
30. Standardization of tinware. ....
31. Standardization of tinware. ....
32. Standardization of tinware. ....
33. Standardization of tinware. ....
34. Standardization of tinware. ....

35. Standardization of tinware. ....

36. Standardization of tinware. ....

37. Standardization of tinware. ....

38. Standardization of tinware. ....

39. Standardization of tinware. ....

40. Standardization of tinware. ....

41. Standardization of tinware. ....

42. Standardization of tinware. ....

43. Standardization of tinware. ....

44. Standardization of tinware. ....

45. Standardization of tinware. ....

46. Standardization of tinware. ....

47. Standardization of tinware. ....

48. Standardization of tinware. ....

49. Standardization of tinware. ....

50. Standardization of tinware. ....

51. Standardization of tinware. ....

52. Standardization of tinware. ....

53. Standardization of tinware. ....

54. Standardization of tinware. ....

55. Instructions in fuel economy. ....

56. Fiber stresses for heat-treated and alloy-steel materials. ....

57. Quenched and tempered carbon-steel axles, etc. ....

58. Quenched and tempered alloy-steel forgings. ....

59. Boiler-washing. ....

Name..

Title and road..................................

Address..

RESULT OF LETTER BALLOT.

To the Members:

The following is the result of the letter ballot vote on standards and recommended practice which closed September 19, 1915:

No.	SUBJECT.	Yes.	No.	Total.	Necessary to Choice.	Result.
1	Specifications for steel axles.....	109	1	110	73	Adopted.
2	Journal box and details.........	110	1	111	74	"
3	Specifications for fire-box steel...	108	4	112	75	"
4	Specifications for forgings.......	109	2	111	74	"
5	Specifications for cylinder castings, etc....................	109	4	113	75	"
6	Specifications for steel castings..	108	4	112	75	"
7	Factor of safety boiler construction.......................	113	......	113	75	"
8	Allowable stress of stays and braces......................	114	......	114	76	"
9	Stay bolt testing..............	112	2	114	76	"
10	Strain gages.................	113	......	113	75	"
11	Safety valves................	113	......	113	75	"
12	Filing reports................	113	......	113	75	Adopted.
13	Specification cards............	113	......	113	75	"
14	Brakes on dead engines.........	106	6	112	75	"
15	Vacant	......	......	......	......	....
16	Vacant	......	......	......	......	....
17	Vacant	......	......	......	......	....
18	Vacant	......	......	......	......	....
19	Vacant	......	......	......	......	....

No.	SUBJECT.	Yes.	No.	Total.	Necessary to Choice.	Result.
20	Methods of photometering......	102	6	108	72	Adopted.
21	Stresses for boilers, rules for determining................	105	7	112	75	"
22	Longitudinal gusset braces and flat surfaces.................	110	3	113	75	"
23	Radial stays and crown bar bolts.	108	3	111	74	"
24	Standardization of tinware......	72	33	105	70	"
25	Standardization of tinware......	80	25	105	70	"
26	Standardization of tinware......	88	15	103	69	"
27	Standardization of tinware......	91	13	104	69	"
28	Standardization of tinware......	98	6	104	69	"
29	Standardization of tinware......	91	13	104	69	"
30	Standardization of tinware......	91	13	104	69	"
31	Standardization of tinware......	83	20	103	69	"
32	Standardization of tinware......	85	17	102	68	"
33	Standardization of tinware......	95	9	104	69	"
34	Standardization of tinware......	86	17	103	69	"
35	Standardization of tinware......	84	19	103	69	"
36	Standardization of tinware......	96	8	104	69	"
37	Standardization of tinware......	80	25	105	70	"
38	Standardization of tinware......	79	25	104	69	"
39	Standardization of tinware......	81	21	102	68	"
40	Standardization of tinware......	81	23	104	69	"
41	Standardization of tinware......	81	23	104	69	"
42	Standardization of tinware......	82	22	104	69	"
43	Standardization of tinware......	98	6	104	69	"
44	Standardization of tinware......	97	7	104	69	"
45	Standardization of tinware......	96	8	104	69	"

No.	SUBJECT.	Yes.	No.	Total.	Necessary to Choice.	Result.
46	Standardization of tinware......	81	23	104	69	Adopted.
47	Standardization of tinware......	71	34	105	70	"
48	Standardization of tinware......	89	16	105	70	"
49	Standardization of tinware......	91	14	105	70	"
50	Standardization of tinware......	97	7	104	69	"
51	Standardization of tinware......	95	9	104	69	"
52	Standardization of tinware......	94	10	104	69	"
53	Standardization of tinware......	94	10	104	69	"
54	Standardization of tinware......	97	7	104	69	"
55	Instructions in fuel economy.....	111	1	112	75	"
56	Fiber stresses for heat treated and alloy-steel materials..........	103	9	112	75	"
57	Quenched and tempered carbon steel axles, etc..............	104	9	113	75	"
58	Quenched and tempered alloy-steel forgings................	103	9	112	75	"
59	Boiler washing................	108	3	111	74	"

JOS. W. TAYLOR,
Secretary

STANDARDS AND RECOMMENDED PRACTICE.

SCREW THREADS, BOLT HEADS AND NUTS. STANDARD.

At the convention of 1870 the report of a committee recommending the United States Standard Screw Thread was adopted. The forms and dimensions of the threads are shown below:

Fig. 1.

Fig.

Fig.

SCREW THREADS. SELLERS' STANDARD.

Mr. Sellers, who proposed this system of screw threads, described it in an essay read before the Franklin Institute of Philadelphia, April 21, 1864, as follows:

"The proportions for the proposed thread and its comparative relation to the sharp and rounded threads, will be readily understood from the accompanying diagram in which Figs. 1 and 2 — the latter on an exaggerated scale — represent a sharp thread, Figs. 3 and 4 a rounded top and bottom to the English proportion, and Figs. 5 and 6 the flat top and bottom, all of the same pitch. The angle of the proposed thread is fixed at sixty degrees, the same as the sharp thread, it being more readily obtained than fifty-five degrees; and more in accordance with the general practice in this country. Divide the pitch, or, which is the same thing, the side of the thread into eight equal parts, take off one part from the top and fill in one part in the bottom of the thread, then the flat top and bottom will equal one-eighth of the pitch; the wearing surface will be three-quarters of the pitch, and the diameter of screw at bottom of the thread will be expressed by the formula:

$$\textit{Diameter} - \frac{1.299}{\textit{number of threads per inch}}.$$

BOLT HEADS AND NUTS. STANDARD.

Sheet M. M. 15.

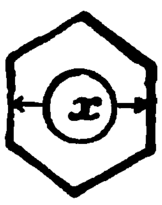
At the convention of 1892 the Association adopted as standard the United States standard sizes of nuts and bolt heads.

At the convention of 1903 the arrangement of these standards was made to conform to the arrangement as adopted by the Master Car Builders' Association.

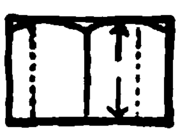
In 1913 the proportions of the bolt heads and nuts were changed and table shown on Sheet M. M. 18 revised.

PROPORTIONS FOR SELLERS' STANDARD NUTS AND BOLTS.

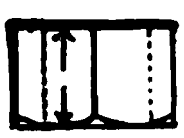
Rough Nut = one and one-half diameter of bolt + $\frac{1}{8}$.



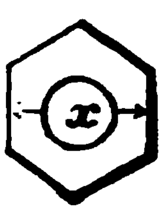
Finished Nut = one and one-half diameter of bolt + $\frac{1}{16}$.



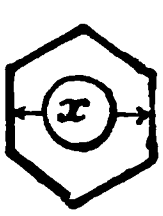
Rough Nut = diameter of bolt.



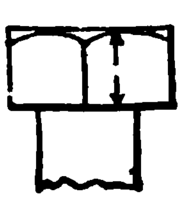
Finished Nut = diameter of bolt—$\frac{1}{16}$.



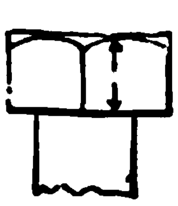
Rough Head = one and one-half diameter of bolt.



Finished Head = one and one-half diameter of bolt — $\frac{1}{16}$.



Rough Head = three-quarter times diameter of bolt.



Finished Head = $\frac{3}{4}$ diameter of bolt—$\frac{1}{16}$.

SQUARE BOLT HEADS. **STANDARD.**

In 1899 the following dimensions for square bolt heads were adopted as standard:

The side of the head shall be one and one-half times the diameter of the bolt, and the thickness of the head shall be one-half the side of the head.

CASTLE NUTS, COTTER PINS AND LOCATION OF COTTER-PIN HOLES IN PROJECTING BOLT ENDS. STANDARD.

Sheet M. M. 18.

At the convention of 1909 a series of dimensions for castle nuts, also cotter pins and bolt ends with cotter-pin location, were submitted by a committee, and on reference to letter ballot were adopted as standard. They are shown on Sheet M. M. 15 herewith, and cover the following:

1. A series of castle nuts having U. S. standard threads.

2. A series of thin castle nuts having U. S. standard threads.

3. A series of special thin castle nuts having outward proportions the same as thin castle nuts, but having a special number of threads.

4. Rough nuts with diameters across the flats as shown. These dimensions correspond with U. S. standard dimensions for hexagon nuts. Finish of flats to be obtained by grinding and buffing, or by milling, the same practice as obtains in the case of U. S. standard nuts.

5. Finished nuts to have facing washer on bottom with dimensions as shown; rough nuts to have bottom corner slightly chamfered.

6. A series of standard cotter pins.

7. A series of Player cotter pins.

8. A series of taper pins.

9. Projecting bolt ends with cotter-pin hole location.

In 1914 a modification of the standard proportions of castle nuts was made to provide for steel nuts with the height of the U. S. standard for rough nuts.

LIMIT GAUGES FOR ROUND IRON. STANDARD.

At the convention of 1884 the Pratt & Whitney limit gauges for round iron, shown below, were adopted as standard. (See page 168, report 1884.) Reaffirmed 1891 (see pages 160, 161, report 1891).

Nominal Diameter of Iron. Inches.	Large Size, End Inches.	Small Size End Inches.	Total Variation, Inches.
1/4	.2550	.2450	.010
5/16	.3180	.3070	.011
3/8	.3810	.3690	.012
7/16	.4440	.4310	.013
1/2	.5070	.4930	.014
9/16	.5700	.5550	.015
5/8	.6330	.6170	.016
3/4	.7585	.7415	.017
7/8	.8840	.8660	.018
1	1 0095	.9905	019
1 1/8	1.1350	1.1150	.020
1 1/4	1.2605	1.2395	.021
1 3/8	1.3860	1.3640	.022
1 1/2	1.5115	1.4885	.023
1 5/8	1.6370	1.6130	.024
1 3/4	1.7625	1.7375	.025
1 7/8	1.8880	1.8620	.026

Round iron 2 inches in diameter and over should be rolled to the nominal diameter.

SPECIFICATION FOR STEEL TIRES. RECOMMENDED PRACTICE.

In 1913 the following specifications for steel tires were adopted as Recommended Practice; in 1914 paragraph No. 7 was modified:

1. MATERIAL.—Stock for tires shall be made by the open-hearth or crucible process.

2. CLASSES.—There will be three classes of tires for the different classes of service, as follows:

Class 1. Driving tires for passenger engines.
Class 2. Driving tires for freight engines.
Class 3. Driving tires for switching engines, and tires for engine truck, tender truck, trailers and car wheels.

3. Chemical Composition:

Class 1.	Carbon, not less than......	50 per cent or over 70 per cent.
	Phosphorus, not over......	05 per cent.
	Manganese, between	50 per cent and 80 per cent.
	Sulphur, not over..........	05 per cent.
Class 2.	Carbon, not less than......	60 per cent or over 80 per cent.
	Phosphorus, not over......	05 per cent.
	Manganese, between	50 per cent and 80 per cent.
	Sulphur, not over..........	05 per cent.
Class 3.	Carbon, not less than......	70 per cent or over 85 per cent.
	Phosphorus, not over......	05 per cent.
	Manganese, between	50 per cent and 80 per cent.
	Sulphur, not over..........	05 per cent.

4. Finish.—The tires must be free from defects of any kind, and finished tires must be accurately machined to the prescribed dimensions of the Master Mechanics' standard, and rough tires must not be outside the limits of the attached prints.

5. Branding.—The tires shall be distinctly stamped when hot with such brands as the purchaser may require, and in such a manner that those marks shall be legible when the tires are worn out.

6. Samples for Chemical Analysis.—Drillings from a small test ingot cast with the heat, or turnings, from a tensile specimen, or turnings from a tire (where tires are machined at the works of the manufacturer) shall be used to determine whether the chemical composition of the heat is within the limits specified in paragraph 3. When required, the purchaser or his representative shall be furnished an analysis of each heat from which tires are made.

7. Physical Properties.—The steel for the different classes of service shall meet the following minimum physical requirements:

Class.	Tensile Strength. Lbs. per sq. in.	Elongation per cent in 2 in.	Reduction in Area, per cent.
(a)	105,000	12	16
(b)	115,000	10	14
(c)	125,000	8	12

(d) The elasticity shall be at least 50 per cent of the tensile strength.

8. Falling Weight Test.—Should the contract call for a falling weight test, a test tire from each heat represented shall be selected by the purchaser or his representative and furnished at his expense, provided it meets the requirements.

8a. The test tire shall be placed vertically under the drop in a running position on a spring foundation with an anvil of at least ten tons weight, and shall be subjected to successive blows, from a tup weighing 2,000 pounds falling from heights of 5 feet, 10 feet, 15 feet and 30 feet and upward, until the required deflection is obtained as specified in paragraph 8b.

8b. The test tire shall stand the drop test described in paragraph 8a without breaking and cracking, and shall show a minimum deflection equal to X in the following table:

Internal diameter of tire (=D). Thickness of tire (=T.)	Class No. 1. Tensile breaking strength per sq. in., 105,000 lbs.	Class No. 2. Tensile breaking strength per sq. in., 115,000 lbs.	Class No. 3. Tensile breaking strength per sq. in., 125,000 lbs.
3 feet diameter and over...	3 d / 6 t	3 d / 10 t	3 d / 12 t
Under 3 feet diameter......	3 d / 10 t	3 d / 12 t	3 d / 14 t

8c. A specimen for the tensile test is to be taken from a tire that has been subjected to a falling weight test, and it shall be cut cold from the tested tire at the point least affected by the falling weight test. The tensile test specimen when cut from a tire that has been subjected to a falling weight test shall be cut normal to the radius and parallel to the face.

8d. Should the test tire fail to meet these requirements in any particular, two or more test tires shall be selected from the same heat if the manufacturer so desires, and at his expense. Should these two tires fulfil the requirements, the heat shall be accepted.

9. Inspection.—The inspector representing the purchaser shall have free entry to the works of the manufacturer at all times while his contract is being executed. All reasonable facilities shall be afforded to the inspector by the manufacturer to satisfy him that the tires are being furnished in accordance with the specifications. All tests and inspections shall be made at the place of manufacture prior to shipment, and shall be conducted so as not to interfere unnecessarily with the operations of the mill.

Tires must be rolled in accordance with the best practice, sufficient metal being discarded to insure sound tires. The tire taken from the bottom of the ingot must be stamped with the letter "A," before the tire number, the next above " B," and so on up the ingot.

Tensile test specimens, one from each heat, must be forwarded to the engineer of tests of the railway company, together with a copy of the chemical analysis of each heat, showing the tire numbers rolled from each heat; also destination of each tire, together with the railway company's purchasing agent's order number. If, however, the manufacturer is rolling tires right along for the railroad company, and their inspector is at their plant, the test specimens from heats ready at that time may be pulled at the manufacturer's plant by the inspector and the broken test pieces sent in for analysis, in which case the above information must be furnished the inspector.

An analysis of the test piece made by the railroad company's test bureau must agree with that furnished by the manufacturer, and with an analysis made from turnings from the tires after received; a failure to agree within reasonable limits will be cause for rejection.

In addition to the above tests, the railroad company reserves the right to make a repetition of any tests to make sure that only material meeting all the requirements set forth in this specification be accepted, and all material found not up to any one or all of these requirements will be rejected.

Samples representing rejected material will be retained in the test bureau not longer than thirty days from date of test. If at the end of that period the sellers have not signified their desire for a rehearing, it will be understood that they agree with the results as reported. If by this time the sellers have not given shipping directions for material rejected at destination, the material represented by the samples will be returnd to them at their risk, they paying the freight both ways.

SECTION OF TIRE. STANDARD.

Sheet M. M. 17.

At the convention of 1893 a form of section of tire was adopted. See Proceedings 1893. Modified in 1908. See Sheet M. M. 1, Proceedings 1908.

In 1912 the form of contour for tread and flange of engine truck and tender truck wheels was changed to the form shown on Fig. 1, Sheet M. M. 1.

In 1912 the form of contour for tread and flange for driving wheel tires of locomotives in switching service was changed to that shown on Fig. 1, and for driving and trailing wheels of locomotives in road service, the form shown in Fig. 2 was retained. See Sheet M. M. 1.

In 1912 a further revision was made in Sheet M. M. 1 by the elimination of the five different widths of flanged tires then shown, allowing but one width, viz.: 5½ inches to be shown. Also in the case of plain tires shown on this sheet two sizes were eliminated, thus showing three sizes, viz.: 6 inches, 6½ inches and 7 inches.

In 1912 a condemning limit of thickness of flange of 15/16 inch was adopted as standard.

In 1913 the illustrations of tire sections were changed to Sheet M. M. 17.

DRIVING-WHEEL CENTERS AND SIZES OF TIRES. STANDARD.

At the convention of 1886 the report of a committee was adopted which recommended driving-wheel centers to be made 38, 44, 50, 56, 62 or 66 inches diameter.

In 1893 the following sizes were added to the standards: 70, 74, 78, 82, 86 and 90 inches.

In 1907, as a result of letter ballot, 72 inches was adopted as a standard size.

In 1907 the following standards were adopted by letter ballot:

Cast-steel driving-wheel centers should preferably be uncut and shrinkage slots omitted; if cut, slots should be machined out and closed with solid cast-iron liners driven in. No lead or white metal should be used.

For wheel centers 60 inches and over, when the permissible total weight of the locomotive will allow, the rims should preferably be cast solid without cores, so as to obtain the maximum section and have full bearing of tires; the section in square inches should be approximately .45 of the sectional area of the tire when new.

The section of rim for wheel centers without retaining rings shall be of the form shown below:

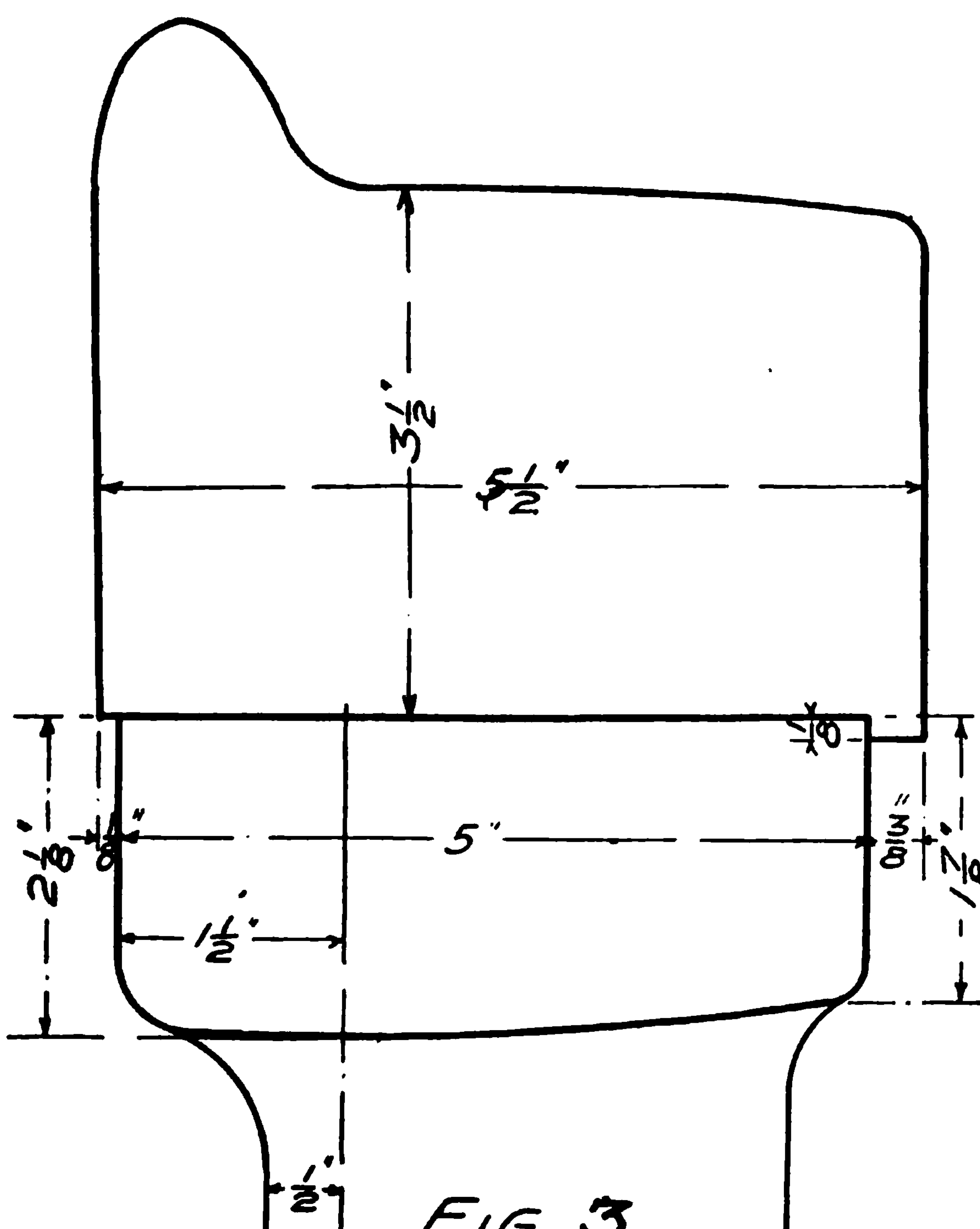


FIG. 3.

The standard distance between hubs shall be 55 inches.

In 1907, as a result of letter ballot, the following standards were adopted:

In order to properly support the rim and resist the tire shrinkage, spokes should be placed from 12 to 13 inches apart from center to center, measured on the outer circumference of the wheel center.

Spokes at crank hub should not be located at center line of wheel, but on either side, so as not to bring a short spoke directly in line with crank-pin hub. Section of spokes at large end to have an area of from 9 to 10 square inches, with form as shown in Fig. 1. Section of spoke at small end to have an area of from 5¾ to 6 square inches, with form as

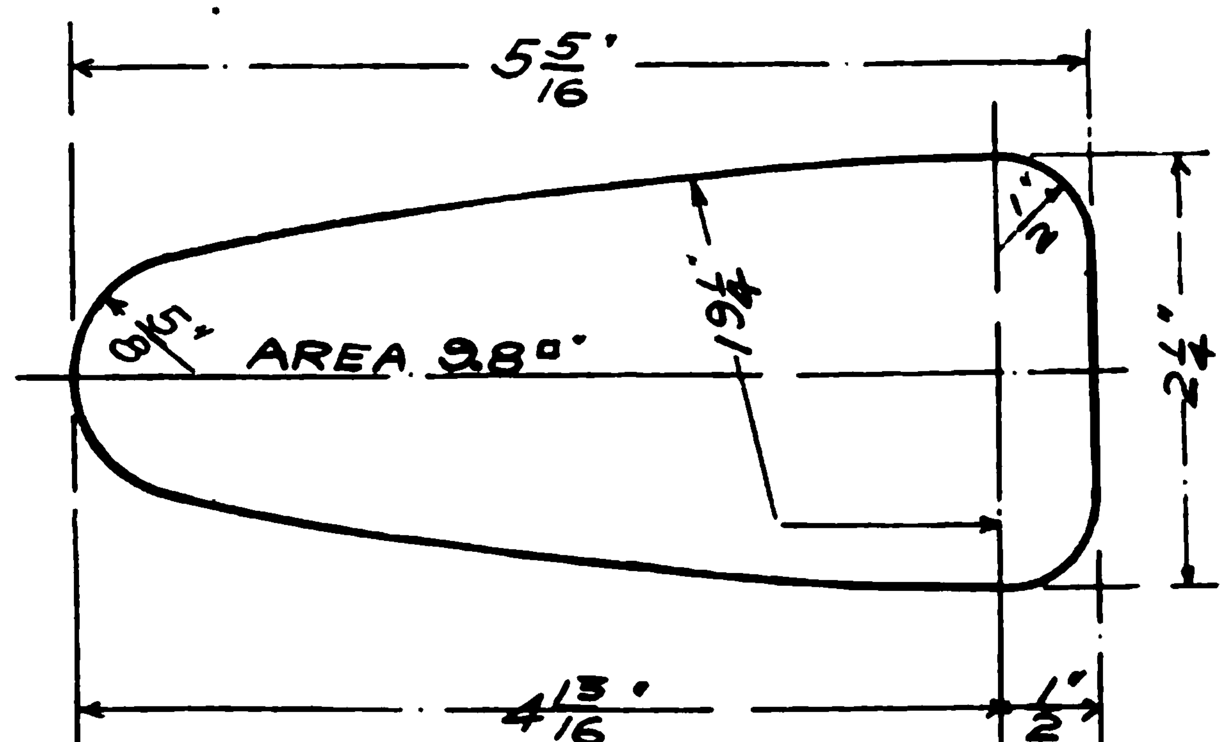


FIG. 1.

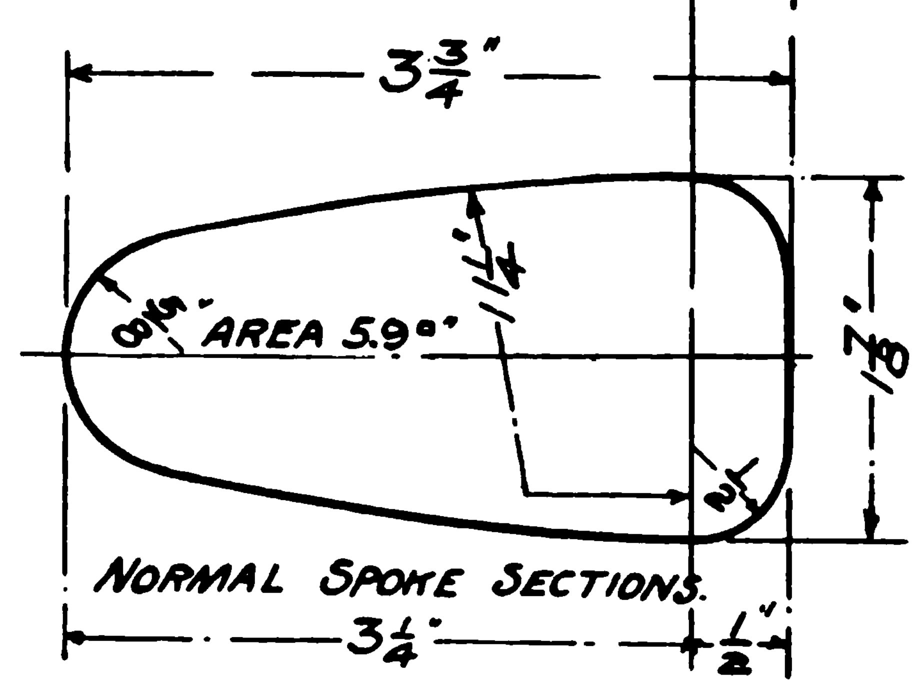


FIG. 2.

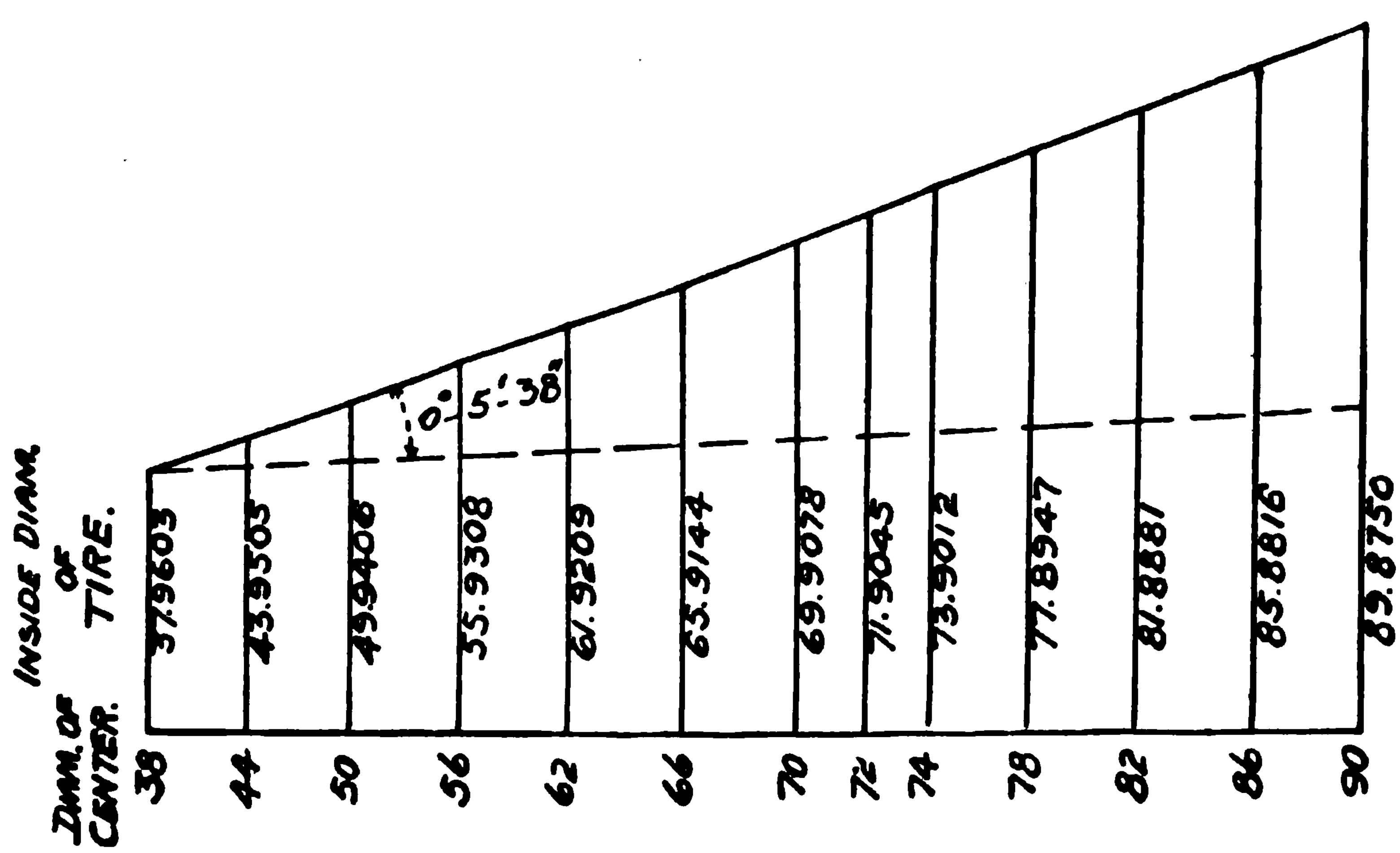
shown in Fig. 2. The sections shown herewith are taken at the base of the fillets uniting the spoke to the hub and rim.

In 1907, as a result of letter ballot, the following shrinkage allowances were adopted as standard:

For cast-iron and cast-steel centers less than 66 inches in diameter, 1-80 inch per foot in diameter.

For cast-iron and cast-steel centers 66 inches and over in diameter, 1-60 inch per foot in diameter.

In 1908 the dimensions shown in diagram below were adopted as standard, allowing 1-80 inch per foot in diameter of 38-inch centers, and 1-60 inch per foot in diameter of 90-inch centers.

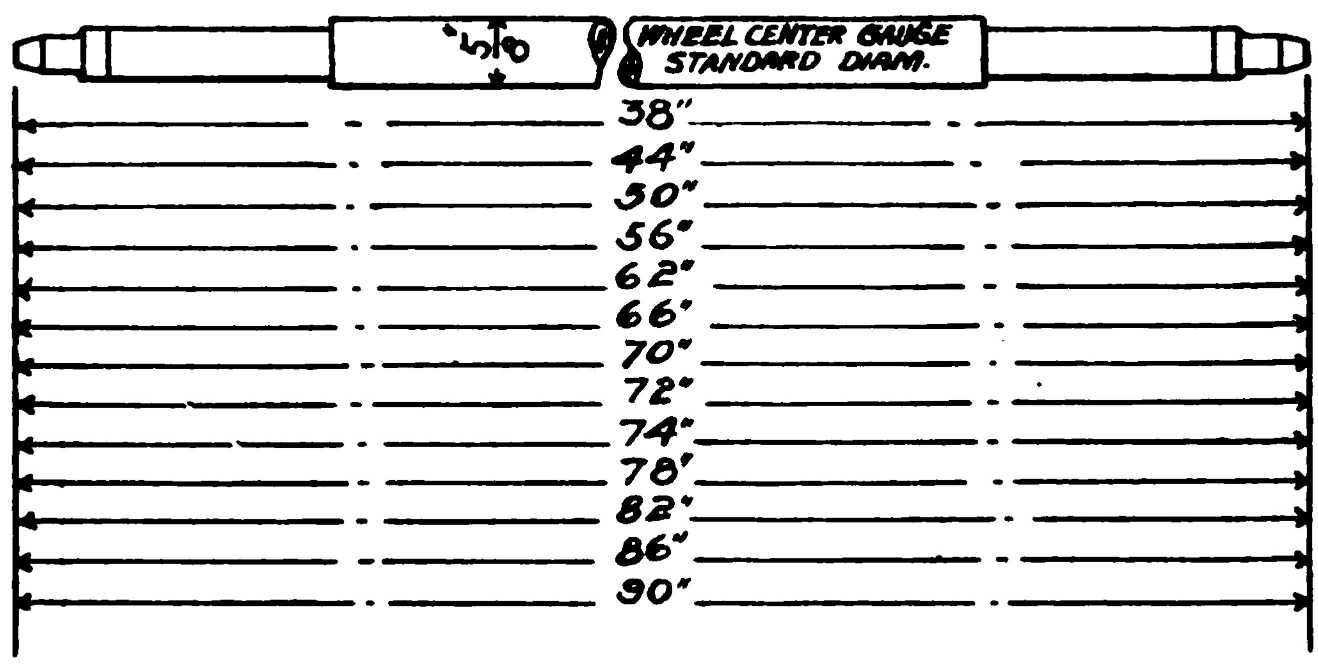


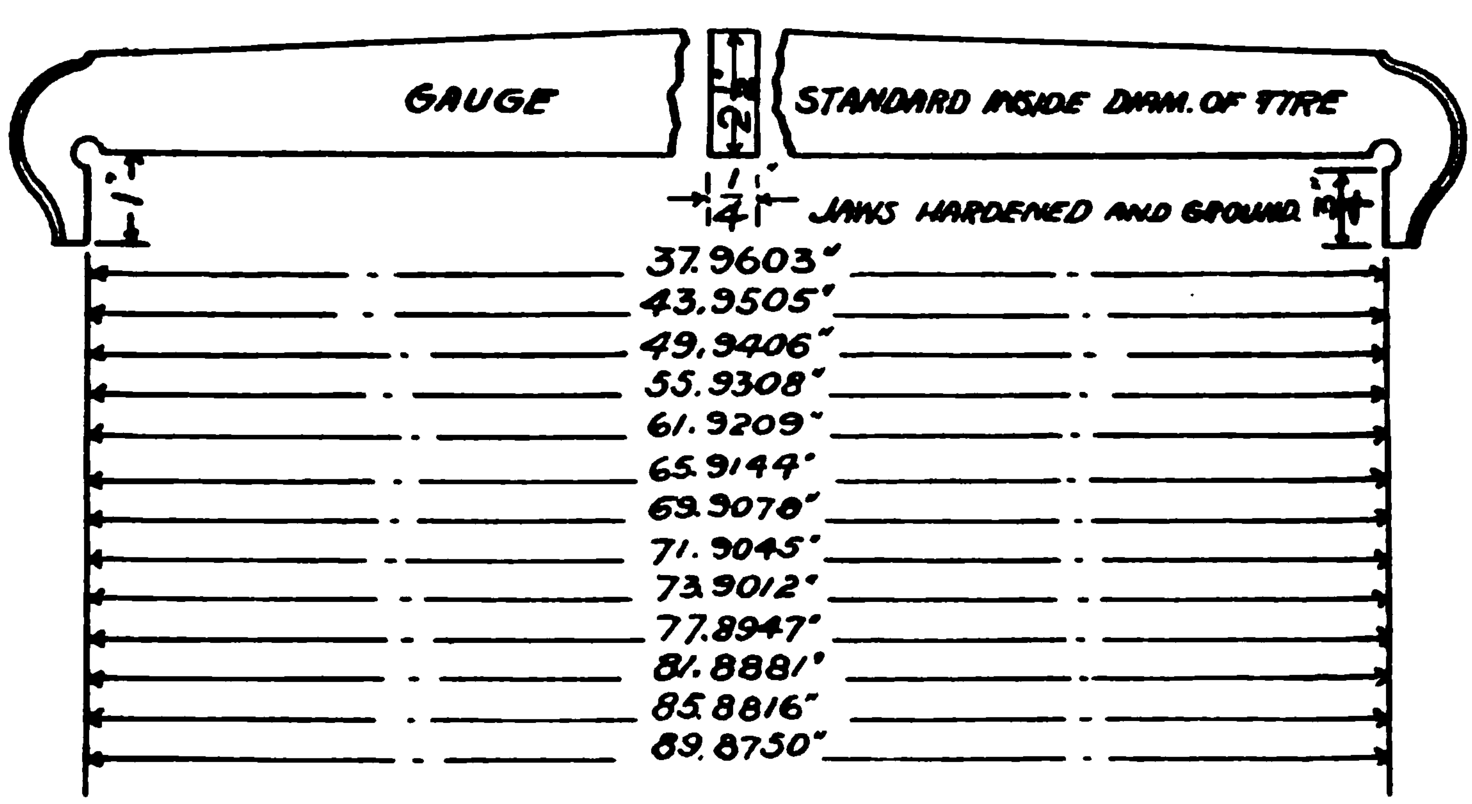
MASTER GAUGES FOR TURNING WHEEL CENTERS AND BORING TIRES. STANDARD.

At the Twentieth Annual Convention the recommendations of a committee were adopted, making tire gauges manufactured by Messrs. Pratt & Whitney, Hartford, Connecticut, standards of the Association.

In 1908 the illustrations of the gauges were made to include the dimensions for all the standard wheel centers and tires.

STANDARD MASTER GAUGES FOR TURNING WHEEL CENTERS & BORING TIRES





AXLES FOR LOCOMOTIVE TENDERS. STANDARD.

Sheet M. M. 1.

Axle A. At the convention of 1879 the Master Car Builders' Standard Axle with 3¾ by 7 inch journals was adopted as Standard. (See pages 14-35, 52-58, report 1879). Changed to Recommendations 1891. (See pages 160, 161, report 1891.) Modified to conform to M. C. B. practice in 1903

and adopted as Standard. Revised 1908. See plate 1. In 1908 this axle was made to conform to the M. C. B. Standard.

Axle B. At the convention of 1890 the Master Car Builders' standard axle with journals 4¼ by 8 inches was adopted as Standard. See page 166, report 1890.) Changed to Recommendations in 1891. (See pages 160, 161, report 1891.) Modified to conform to M. C. B. practice in 1903 and adopted as Standard. Revised 1908. See plate 1.

Axle C. At the convention of 1903 the Master Car Builders' standard axle with 5 by 9 inch journals was adopted as Standard. See report of Committee on Revision of Standards, 1903. See plate 1.

Axle D. At the convention of 1903 the Master Car Builders' standard axle with journals 5½ by 10 inches was made a Standard.

Axle E. In 1913 M. C. B. Axle E was adopted as Standard.

SPECIFICATIONS FOR AXLES.

In 1908 specifications for axles, as prescribed by the M. C. B. Association, were adopted as Standard. In 1913 the specifications for iron axles were dropped from the Standards.

SPECIFICATIONS FOR STEEL AXLES FOR LOCOMOTIVE TENDERS. STANDARD.

I. MANUFACTURE.

1. **PROCESS.**— The steel shall be made by the open-hearth process.

II. CHEMICAL PROPERTIES AND TESTS.

2. **CHEMICAL COMPOSITION.**— The steel shall conform to the following requirements as to chemical composition:

Carbon	0.38-0.52 per cent
Manganese	0.40-0.60 per cent
Phosphorus, not over	0.05 per cent
Sulphur, not over	0.05 per cent

3. **LADLE ANALYSIS.**—An analysis shall be made by the manufacturer from a test ingot taken during the pouring of each melt, to determine the percentage of carbon, manganese, phosphorus, sulphur and silicon. Drillings for analysis shall be taken not less than ¼ in. beneath the surface of the test ingot. A copy of this analysis shall be given the purchaser or his representative. This analysis shall conform to the requirements specified in Section 2.

4. **CHECK ANALYSIS.**—A check analysis shall be made from the finished material representing each melt, by the purchaser or his representative, and shall meet the requirements specified in Section 2.

III. Physical Properties and Tests.

5. **DROP TESTS.**— The axles shall conform to the following drop-test requirements:

(a) The test axle shall be so placed on the supports that the tup will strike it midway between the ends. It shall be turned over after the first and third blows, and when required after the fifth blow. When tested in accordance with following conditions, the axle shall stand the specified number of blows without fracture, and the deflection after the first blow shall not exceed that specified in Table No. 1.

Size of Axle, In.		Capacity of Axle, Lb.	Distance between Supports Ft.	Weight of Tup, Lb.					
				1 640			2 200		
Journal.	Diam. at Center.			Height of Drop, Ft.	Number of Blows.	Max. Deflection, In.	Height of Drop, Ft.	Number of Blows.	Max. Deflection, In.
4¼ by 8	4¾	22 000	3	34	5	7½	.....	.....	....
5 by 9	5⅜	31 000	3	43	5	6¼	......	......	....
5½ by 10	5⅞	38 000	3	43	7	4½	......	....	....
6 by 11	$6\frac{7}{16}$	50 000	3	.....	......	.....	40	7	5⅛

(b) The deflection is the difference between the distance from a straight-edge to the middle point of the axle, measured before the first blow, and the distance measured in the same manner after the blow. The straight-edge shall rest only on the collars or the ends of the axle.

6. **DROP-TEST MACHINE.**— The anvil of the drop-test machine shall be supported on 12 springs, as shown on the M. C. B. drawings, and shall be free to move in a vertical direction, and shall weigh 17,500 lb. The radii of the striking face of the tup and of the supports shall be 5 in.

7. **NUMBER OF TESTS.**—(a) One drop test shall be made from each melt. Unless otherwise specified, not less than 30 axles shall be offered from any one melt.

(b) If the test axle passes the physical tests, the inspector shall draw a straight line 10 in. long parallel with the axis of the axle, and starting with one end of it he shall prick-punch this line at several points. A piece 6 in. long shall be cut off from this same axle so as to leave some prick-punch marks on each piece of axle. Drillings for chemical analysis shall be taken by using a ⅝-in. drill and drilling in the cut-off end 50 per cent of the distance from the center to the circumference and parallel with the axis of the axle.

IV. Workmanship and Finish.

8. **WORKMANSHIP.**—All axles shall be made and finished in a workmanlike manner and all journals and wheel seats shall be rough-

turned. In centering, unless otherwise specified, 60 deg. centers shall be used, with large diameter of counter-sink not less than 7/8 in., and with clearance drilled 1/2 in. deep.

9. **FINISH.**— The axles shall be free from injurious defects and shall have a workmanlike finish.

V. Permissible Variations and Weights.

10. **PERMISSIBLE VARIATION.**— The axle shall conform in size and shape to the standard M. M. drawings (see Sheet No. 1). Length shall not be less than shown and not more than 1/32 in. over.

VI. Marking and Storing.

11. **MARKING.**— The manufacturer's name or brand, melt number and month and year when made shall be legibly stamped on each axle on the unfinished portion, unless otherwise specified.

12. **STORING.**— If, as a result of the inspection and tests, more axles are accepted than the order calls for, such accepted axles in excess shail be stamped by the inspector with his own name, and will then be piled and allowed to remain in stock at the works, subject to further orders from the purchasing agent. On receipt of further orders, axles once accepted will not be subjected to further test. In all cases the inspector will keep an accurate record of the melt numbers and the number of axles in each melt which are stored and will transmit this information with each report.

VII. Inspection and Rejection.

13. **INSPECTION.**—(a) The inspector shall examine each axle in each melt for workmanship, defects, and to see whether the axles conform to the dimensions given on the order or tracing, or whether they conform to the specifications. All axles not satisfactory in these respects shall not be considered further. If in this inspection defects are found which the manufacturer can remedy while the inspector is at the works, he may be allowed to correct such defects.

(b) The inspector representing the purchaser shall have free entry at all times, while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the material ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications.

(c) The purchaser may make the tests to govern the acceptance or rejection of material in his own laboratory or elsewhere. Such tests, however, shall be made at the expense of the purchaser.

(d) All tests and inspection shall be so conducted as not to interfere unnecessarily with the operation of the works.

14. **REJECTION.**— Material which, subsequently to above tests at the mills or elsewhere, and its acceptance, develops imperfections shall be rejected and shall be replaced by the manufacturer at his own expense.

15. **REHEARING.**— Samples tested in accordance with this specification, which represent rejected material, shall be preserved 14 days from date of test report. In case of dissatisfaction with results of the tests, the manufacturer may make claim for a rehearing within that time.

JOURNAL BOX, BEARING AND WEDGES. STANDARD.

JOURNAL BOX AND DETAILS. STANDARD.

For journals 3¾ by 7 inches. Sheets M. M. 2, 3 and 4.

At the convention of 1903 the M. C. B. journal box and contained parts for the 3¾ by 7 inch journal, as shown on Sheets, 2, 3 and 4, were made a Standard of the Association. Revised 1908.

In 1915 a hole was added to the front flange of wedge to facilitate removal by the use of packing hook.

In 1915 the arc recess of each side of the wedge was made optional.

JOURNAL BOX AND DETAILS. STANDARD.

For journals 4¼ by 8 inches. Sheets M. M. 5, 6 and 7.

At the convention of 1903 the M. C. B. journal box and contained parts for the 4¼ by 8 inch journal, as shown on Sheets 5, 6 and 7, were made a Standard of the Association. Revised 1908.

In 1915 a hole was added to the front flange of wedge to facilitate removal by the use of packing hook.

In 1915 the arc recess of each side of the wedge was made optional.

JOURNAL BOX AND DETAILS. STANDARD.

For journals 5 by 9 inches. Sheets M. M. 8, 9 and 10.

At the convention of 1903 the M. C. B. journal box and contained parts for the 5 by 9 inch journal, as shown on Sheets 8, 9 and 10, were made a Standard of the Association.

In 1913 the dust-guard opening was made to conform to the M. C. B. practice.

In 1913 the increased end bearing on wedge, to conform to M. C. B. practice, was adopted.

In 1914 the use of skeleton wedges was discontinued.

In 1915 a hole was added to the front flange of wedge to facilitate removal by the use of packing hook.

In 1915 the arc recess of each side of the wedge was made optional.

JOURNAL BOX AND DETAILS. STANDARD.

For journals 5½ by 10 inches. Sheets M. M. 11, 12 and 13.

At the convention of 1903 the M. C. B. journal box and contained parts for the 5½ by 10 inch journal, as shown on Sheets 11, 12 and 13, were made a Standard of the Association. Revised 1908.

In 1913 the note as to material used in manufacture on Sheet 11 was changed to conform to M. C. B. practice.

In 1913 the increased end bearing on wedge, to conform to M. C. B. practice, was adopted.

In 1914 the use of skeleton wedges was discontinued.

In 1915 a hole was added to the front flange of wedge to facilitate removal by the use of packing hook.

In 1915 the arc recess of each side of the wedge was made optional.

JOURNAL BOX AND DETAILS. STANDARD.

For journals 6 by 11 inches. Sheets M. M. 14, 15 and 16.

In 1914 journal box and contained parts for 6 by 11 inch journals were adopted as Recommended Practice. Advanced to Standard 1915.

SPECIFICATIONS AND TESTS FOR CAST-IRON WHEELS.

At the convention of 1888 the following Specifications and Tests for Cast-iron Wheels were adopted as standard. (See pages 151-154, report 1888.) In 1891 these were changed to Recommendations. (See pages 160, 161, report 1891.)

In 1908 these were modified and changed to standard and the form of contract omitted.

In 1909 designs for wheels for cars of 60,000 pounds, 80,000 pounds and 100,000 pounds capacity were adopted as Standard. Revised 1913.

SPECIFICATIONS FOR 33-INCH CAST-IRON WHEELS FOR TENDERS OF 95,000 POUNDS, 132,000 POUNDS AND 161,000 POUNDS GROSS WEIGHT. RECOMMENDED PRACTICE.

Sheets M. M.—E, F and G.

Adopted 1893. Revised 1899 and 1904. Modified 1911 in reference to cast date. In 1912 the measuring line for nominal diameter was designated as A. B. and the diameters of cores added to drawings. M. C. B. Association revised and rearranged specifications adopted in 1913.

I. MATERIAL AND CHILL.

1. The wheels shall show clean, gray iron in the plates, except at chaplets, where mottling to not more than ½ in. from same will be permitted. The depth of pure white iron shall not exceed 1 in. nor be less than ½ in. in the middle of the tread.

(a) It shall not exceed 1 in. in the middle of the tread nor be less than $\frac{3}{8}$ in. in throat for wheels having a maximum weight of 625 lbs.

(b) It shall not exceed 1 in. in the middle of the tread nor be less than $\frac{7}{16}$ in. in the throat for wheels having a maximum weight of 675 lbs.

(c) It shall not exceed 1 in. in the tread nor be less than $\frac{1}{2}$ in. in the throat for wheels having a maximum weight of 725 lbs.

(d) The depth of white iron shall not vary more than $\frac{1}{4}$ in. around the tread on the rail line in the same wheel.

II. PHYSICAL PROPERTIES AND TESTS.

2. SAMPLING.— When ready for inspection, the wheels shall be arranged in groups, all wheels of the same date being grouped together, and for each 100 wheels which pass inspection and are ready for shipment, two representative wheels shall be taken at random, one of which will be subjected to the drop test.

3. DROP TEST.— The wheels shall conform to the following drop-test requirements:

(a) The test wheel shall be so placed on the three supports, with flange turned downward, that the tup will strike centrally on the hub. When tested in accordance with the following conditions, the wheel shall stand the specific number of blows without fracture:

TABLE I.

Weight of Wheel, Pounds.	Weight of Tup, Pounds.	Height of Drop, Feet.	Number of Blows.
625	200	9	10
675	200	10	12
725	200	12	12

4. THERMAL TEST.— Should the test wheel stand the given number of blows without breaking into two or more pieces, the inspector will then subject the other wheel to the following test:

(a) PREPARATION.— The wheel shall be laid with the flange downward in the sand and a channel way $1\frac{1}{2}$ in. wide and 4 in. deep must be molded with green sand around the wheel. The clean tread of the wheel must form one side of the channel way and the clean flange must form as much of the bottom as its width will cover.

(b) TEST.— The above described channel must be filled with molten cast iron, which shall be hot enough when poured, so that the ring which is formed, when the metal is cold, shall be solid or free from wrinkles or layers. The time when pouring ceases must be noted, and two minutes later an examination of the wheel must be made. If the wheel is found

broken in pieces or if any cracks in the plate extend through or into the rim, all wheels of the same tape size as the wheel broken will be rejected.

5. Drop-test Machine.— The three supports shall not be more than 5 in. wide. The anvil shall be supported on rubble masonry at least 2 feet wide and shall weigh not less than 1,700 lbs. The striking face of the tup shall be 8 in. in diameter and be flat.

III. RETEST.

6. Number of Tests.— In making the drop test, should the test wheel break into two or more pieces with less than the required number of blows, then the second wheel shall be taken from the same lot and similarly tested. If the second wheel stands the test it shall be optional with the inspector whether he shall test the third wheel or not. If he does not do so, or if he does and the third wheel stands the test, the 100 wheels will be accepted as filling the requirements of the drop test.

IV. DIMENSIONS, TAPING AND GAUGING.

7. Dimensions.— The normal diameter of the wheel produced by the chill must be the M. M. standard 33 in., measured at a point 2⅝ in. from the outside of the tread of the wheel. Wheels furnished under this specification shall not vary more than ¼ in. above or below the normal size measured on the circumference and the same wheel shall not vary more than $\frac{1}{16}$ in. in diameter.

The thickness of the flange shall be regulated by the maximum and minimum flange thickness gauges adopted by the American Railway Master Mechanics.

8. Taping.— All wheels shall be taped with M. M. standard design of wheel circumference tape, having numbers 1, 2, 3, 4 and 5 stamped ⅛ in. apart, the figure 3 to represent the normal diameter 103.67 in. circumference. The figure 1, the smallest, and the figure 5 the largest.

V. WEIGHTS.

9. All wheels furnished under these specifications shall conform to the respective sections shown by the M. M. drawings for different weights of wheels and weights shall be as follows:

Maximum Gross Weight of Tenders, Pounds.	Maximum Weight of Wheel Not Exceeding, Pounds.	Minimum Weight of Wheel Not Less Than, Pounds.
112,000	625	615
132,000	675	665
161,000	725	715

(a) Cores.— In case of wheels ordered with cores smaller in diameter than the standard, the additional weight should be considered as an addition to the normal weight and paid for by the purchaser.

(b) Note.— Weights given in the above table are based on M. M. Standard drawings covering wheel design.

10. Under Weight.— Wheels that are under minimum weight will be set aside and not further considered.

11. Over Weight.— Wheels that are over the maximum weights will be at the expense of the manufacturer.

VI. WORKMANSHIP AND FINISH.

12. Workmanship.— Chills shall have an inside profile that, in the finished wheel, will produce the exact form of the flange and tread contour shown by the M. M. drawings.

13. Finish.— The body of the wheel must be smooth and free from slag, shrinkage or blow holes. The tread shall be free from deep and irregular wrinkles, slag, chill cracks and sweat or beads in the throat and swelled rims.

VII. MARKING.

14. Marking.— All wheels shall be numbered consecutively in accordance with the instructions from the railroad company purchasing them, and shall have the initials of such railroad company, also the wheel number, the weight of the wheel and month, day and year when made plainly formed on the inside plate of casting. No two wheels shall have the same number. All wheels shall also have the name and place of manufacture plainly formed on the outside plate in casting. Wheels conforming to the requirements and furnished under this specification shall have the letters M. C. B. 1909 plainly formed on the outside plate in casting.

VIII. REJECTION LIMITS.

15. If in any lot of wheels submitted for test, the test wheel fails to meet the requirements of the drop, chill or thermal test, then all of the wheels in tape number and weight corresponding to the test wheel will be rejected.

(a) High Chill.— In case the rejection is for high chill, weak breaking strength, or failure in the thermal test, the test will be continued in the next higher number of tape size.

(b) Low Chill.— If the rejection is for low chill, the test will be continued in the next lower number tape size.

WHEEL TREAD AND FLANGE FOR CAST-IRON WHEELS. STANDARD.

Sheet M. M. 17.

In 1908 a wheel tread and flange for cast-iron wheels was adopted as Standard as a part of the specifications for cast-iron wheels.

DISTANCE BETWEEN BACKS OF FLANGES OF STEEL-TIRED ENGINE TRUCK, DRIVER OR TENDER WHEELS. STANDARD.

At the convention of 1884, a motion prevailed that the standard distance between the backs of tires for tender locomotive truck and driving wheels be not less than 4 feet 5⅛ inches, nor more than 4 feet 5½ inches. (See page 26, report 1884.) Modified in 1903. See report of Committee on Revision of Standards.

In 1908 the above standard was made applicable to steel-tired engine truck, driver or tender wheels.

TERMS AND GAUGING POINTS FOR WHEELS AND TRACK. RECOMMENDED PRACTICE.

Sheet M. M.—A.

In 1913 terms and gauging points for wheels and track were adopted as Recommended Practice, as follows:

1. TRACK RAILS are the two main rails forming the track.

2. GAUGE OF TRACK is the shortest distance between the heads of track rails.

3. BASE LINE, for wheel gauges, is a line parallel to the axis of the wheels drawn through the point of intersection of tread with a line perpendicular to the axis, and passing through the center of the throat curve.

4. INSIDE GAUGE OF FLANGES is the distance between backs of flanges of a pair of mounted wheels measured on the base line.

5. GAUGE OF WHEELS is the distance between the outside face of flanges of a pair of mounted wheels measured on a line parallel to the base line, but ⅝ inch farther from the axis of the wheels.

6. THICKNESS OF FLANGE is the distance measured parallel to the base line between two lines perpendicular thereto, one drawn through the point of measurement of "inside gauge of flanges," and the other drawn through the point of measurement of "gauge of wheels."

7. WIDTH OF TREAD is the distance measured parallel to the base line from a line perpendicular thereto, drawn through the point of measurement of "gauge of wheels" to the outer edge of tread.

8. CHECK GAUGE DISTANCE is the distance measured parallel to the base line between two lines perpendicular thereto, one drawn through the point of measurement of "inside gauge of flanges" on either wheel, and the other drawn through point of measurement of "gauge of wheels" on mate wheel.

9. OVER ALL GAUGE is the distance parallel to base line from outer edge of one wheel to the outer edge of mate wheel.

The above mentioned wheel gauge distances are either directly or by inference as follows:

	Feet.	Inches.
Inside Gauge of Flanges......................	4	5 7-32
Gauge of Wheels..............................	4	7 11-16
Thickness of Flange..........................	..	1 11-32
Width of Tread...............................	..	4 11-32
Check Gauge Distance.........................	4	6 29-64
Over All Gauge...............................	5	4⅛

GUARD RAIL AND FROG WING GAUGE. RECOMMENDED PRACTICE.

Sheet M. M.—A.

In 1913 the guard rail and frog wing gauge shown on Sheet A was adopted as Recommended Practice.

WHEEL MOUNTING AND CHECK GAUGE. RECOMMENDED PRACTICE.

Sheet M. M.—A.

In 1913 a reference gauge for mounting and inspecting wheels, as shown on Sheet A, was adopted as Recommended Practice.

LIMIT GAUGES FOR INSPECTING SECONDHAND WHEELS FOR REMOUNTING. RECOMMENDED PRACTICE.

Sheet M. M.—A.

In 1913 limit gauges for use at shops for inspecting secondhand cast-iron wheels for remounting were adopted as Recommended Practice.

WHEEL CIRCUMFERENCE MEASURE FOR CAST-IRON WHEELS. STANDARD.

Sheet M. M. 20.

In 1908 this measure was adopted as Standard for cast-iron wheels as a part of the specifications for cast-iron wheels. Revised in 1913.

WHEEL DEFECT AND WORN COUPLER LIMIT GAUGE. STANDARD.

Sheet M. M. 17.

In 1908 a wheel defect gauge was adopted as Standard. Modified in 1909. Cuts showing use of this gauge for measuring worn wheels was added to sheet in 1909. In 1914 the gauge had a notch added for measuring flat spots 1 inch and 2 inches in length.

GAUGES FOR WHEELS.

MAXIMUM AND MINIMUM FLANGE THICKNESS GAUGE. STANDARD.

Sheet M. M. 17.

In 1908 a maximum and minimum flange thickness gauge was adopted as Standard. Modified in 1909. Revised in 1913 to combine a maximum

and minimum thickness, height and throat radius gauge for solid steel and steel-tired wheels.

In 1914 gauge was corrected to have radius with which the gauging point at throat is struck from 5/8 to 1 13/32 inch. Likewise the 5/8-inch radius, as shown for minimum flange-thickness gauge, was changed to 1 13/32 inch.

SPECIFICATIONS FOR SOLID WROUGHT CARBON STEEL WHEELS. RECOMMENDED PRACTICE.

Sheets M. M.— H, I, J and K.

In 1913 the following specifications for solid wrought carbon steel wheels for locomotive and tender service were adopted as Recommended Practice.

In 1913 designs for wheels as above, for engine and tender trucks, as shown on Sheets M. M.— H, I, J and K, were adopted as Recommended Practice. In 1914 revised as to branding.

Specification for solid wrought carbon steel wheels for locomotive and tender service:

I.— MANUFACTURE.

1a. PROCESS.— The steel shall be made by the open-hearth process.

1b. DISCARD.— A sufficient discard shall be made from the top of each ingot from which the blanks are made, to insure freedom from injurious piping and undue segregation.

II.— CHEMICAL PROPERTIES AND TESTS.

2a. CHEMICAL COMPOSITION.— The steel shall conform to the following requirements as to chemical composition:

	ACID.	BASIC.
Carbon	0.60-0.80	0.65-0.85 per cent.
Manganese	0.55-0.80	0.55-0.80 per cent.
Silicon	0.15-0.35	0.10-0.30 per cent.
Phosphorus	Not over 0.05	Not over 0.05 per cent.
Sulphur	Not over 0.05	Not over 0.05 per cent.

2b. LADLE ANALYSES.— To determine whether the material conforms to the requirements specified in Section II, an analysis shall be made by the manufacturer from a test ingot taken during the pouring of each melt. A copy of this analysis shall be given to the purchaser or his representative.

2c. CHECK ANALYSES.— A check analysis may be made by the purchaser from any one or more wheels representing each melt and this analysis shall conform to the requirements specified in Section II. A sample may be taken from any one point in the plate or two samples may be taken, in which case they shall be on radii at right angles to each other. Samples shall not be taken in such a way as to impair the usefulness of the wheel. Drilling for analysis shall be taken by boring entirely through the sample parallel to the axis of the wheel; they shall be clean from scale, oil and

other foreign substances. All drillings from any one wheel shall be thoroughly mixed together.

III.— TOLERANCES.

3. Wheels should be furnished rough-bored and with faced hubs, and have a contour of tread and flange as rolled or machined according to M. M. Recommended Practice, Sheet 1, Fig. 1. They shall conform to dimensions specified on drawing shown on Sheets M. M.— H, I, J and K, within the following tolerances:

3a. HEIGHT OF FLANGE.— The height of flanges should not be more than 1/8 inch over and must not be under that specified, or 1 inch.

3b. THICKNESS OF FLANGE.— The thickness of flange shall not vary more than 1/16 inch over or under that specified.

3c. THROAT RADIUS.— The radius of the throat shall not vary more than 1/16 inch over or under that specified.

3d. THICKNESS OF RIM.— The thickness of rim to be measured between the limit-of-wear groove and the top of the tread at the point where it joins the fillet at throat of flange. The average thickness of service metal of all wheels in any shipment must not be less than 1 3/4 inches, measured from the limit-of-wear groove to top of tread. The thickness of rim should in no case be less than 3/16 inch under that specified.

3e. WIDTH OF RIM.— The width of rim shall not be more than 1/8 inch less, nor more than 1/8 inch over that specified.

3f. THICKNESS OF PLATE.— The thickness of the plate of the wheel shall not be less than 3/4 inch at the point where the plate joins the fillet at the rim and not less than 1 inch at the point where the plate joins the fillet at the hub. Intermediate minimum thickness to be proportional.

3g. LIMIT-OF-WEAR GROOVE.— The limit-of-wear groove to be located as shown on wheel drawings. M. M. Recommended Practice.

3h. DIAMETER OF BORE.— The diameter of rough bore shall not vary more than 1/16 inch above or below that specified. When not specified, the rough bore shall be 1/4 inch less in diameter than the finished bore, subject to the above limitations.

3i. HUB DIAMETER.— The hub may be either 10 inches or 11 inches in diameter, as specified for tender wheels and outside hub of engine wheels, and 13 1/2 inches and 15 inches in diameter for inside hubs on engine truck wheels. Maximum variation of 1/8 inch below. The thickness of the wall of the finished bored hub shall not vary more than 3/8 inch at any two points on the same wheel.

3j. HUB LENGTH.— The length of the hub shall not vary more than 1/8 inch over or under that specified.

3k. DEPRESSION OF HUB.— The depression of the hub must be made so that the distance from the outside face of the hub to the line "AB" shall not exceed 1 11/16 inches for tender wheels on 5 1/2-inch axles and under, and 1 7/16 inches for tender wheels on 6 by 11 inch axles. For engine

truck wheels the distance from the inside face of the hub to the line "AB" shall not exceed 3$\frac{5}{16}$ inches.

3l. BLACK SPOTS IN HUB.— Black spots will be allowed within 2 inches of the face of the hub, but must not be of such depth that they will not bore out and give clear metal at finished size of bore.

3m. ECCENTRICITY OF BORE.— The eccentricity between the tread at its center line and the rough bore shall not exceed $\frac{3}{64}$ inch.

3n. BLOCK MARKS ON TREAD.— The maximum height of block marks must not be greater than $\frac{1}{64}$ inch.

3o. ROTUNDITY.— All wheels shall be gauged with a ring gauge and the opening between the gauge and tread at any one point shall not exceed $\frac{1}{16}$ inch.

3p. PLANE.— Wheel shall be gauged with a ring gauge placed concentric and perpendicular to the axis of the wheel. All points on the back of the rim equidistant from the center shall be within a variation of $\frac{1}{16}$ inch from the plane of the gauge when so placed.

3q. TAPE SIZES.— Wheels shall not vary more than five tapes under nor nine tapes over the size called for.

3r. MATING.— The tape sizes shall be marked in plain figures on each wheel. Wheels must be mated to tape sizes and shipped in pairs.

3s. GAUGE.— Gauges and tape used shall be M. M. Recomemnded Practice, as follows:

Wheel-circumference measure.
Maximum flange-thickness gauge.
Minimum flange-thickness gauge.
Rotundity gauge.
Gauge for measuring service metal.
Plane gauge.

IV.— BRANDING.

The name or brand of the manufacturer, date and serial number shall be legibly stamped on each wheel; also purchaser's name and serial number, if specified. The tape size shall be legibly marked on each wheel. Arrangement of letters shown on Sheet No. D, M. M. Recommended Practice.

V.— FINISH.

5. The wheel shall be free from injurious defects, and shall have a workmanlike finish.

5a. Wheels shall not be offered for inspection if covered with paint, rust, or any other substance to such an extent as to hide defects.

VI.— INSPECTION.

6. Inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed,

to all parts of the manufacturer's works which concern the manufacture of the material ordered.

6a. The manufacturer shall afford the inspector, free of cost, all reasonable facilities and necessary gauges to satisfy him that the wheels are being furnished in accordance with these specifications. Tests and inspection at the place of manufacture shall be made prior to shipment, and free of cost to the purchaser.

6b. The purchaser may make the tests to govern the acceptance or rejection of material in his own laboratory or elsewhere as may be decided by the purchaser. Such tests, however, shall be made at the expense of the purchaser.

6c. All tests and inspection shall be so conducted as not to interfere unnecessarily with the operation of the works.

6d. Wheels that show injurious defects while being finished by the purchaser shall be rejected, and manufacturer properly notified.

6e. Samples of rejected material must be preserved at the laboratory of the purchaser for one month from date of test report. In case of dissatisfaction with the results of the test, manufacturer may make claim for a rehearing in that time.

WHEEL CIRCUMFERENCE MEASURE FOR STEEL AND STEEL-TIRED WHEELS. RECOMMENDED PRACTICE.

Sheet M. M.— B.

In 1913 a wheel circumference measure for steel and steel-tired wheels was adopted as Recommended Practice.

TIRE FASTENING FOR STEEL-TIRED WHEELS. RECOMMENDED PRACTICE.

Sheet M. M.— B.

In 1913 a tire fastening for steel-tired wheels was adopted as Recommended Practice.

MINIMUM THICKNESS FOR STEEL TIRES. RECOMMENDED PRACTICE.

Sheet M. M.— B.

In 1913 a minimum thickness or limit of wear for steel tires with retaining-ring fastening, shrinkage fastening only, retaining-ring fastening and solid-steel wheel was adopted as Recommended Practice.

ROTUNDITY GAUGE FOR SOLID-STEEL ENGINE AND TRUCK WHEELS. RECOMMENDED PRACTICE.

Sheet M. M.— B.

In 1913 a rotundity gauge for 30-inch, 33-inch, 36-inch and 38-inch solid-steel engine and tender truck wheels was adopted as Recommended Practice.

PLANE GAUGE FOR SOLID-STEEL WHEELS. RECOMMENDED PRACTICE.

Sheet M. M.— B.

In 1913 a plane gauge for solid-steel wheels was adopted as Recommended Practice.

GAUGE FOR MEASURING STEEL WHEELS TO RESTORE CONTOUR. RECOMMENDED PRACTICE.

Sheet M. M.— C.

In 1913 a gauge was adopted to measure the thickness of the rim above the limit-of-wear groove. With this gauge it is possible to measure direct the amount of metal necessary to remove in order to restore the tread to the M. M. contour; also to measure direct the amount of service metal remaining above the condemning limit after the tread is restored to M. M. contour.

BRANDING SOLID-STEEL WHEELS AND DETAILS OF LETTERS AND FIGURES. RECOMMENDED PRACTICE.

Sheet M. M.— D.

In 1913 a method of branding solid-steel wheels and size of letters for same was adopted as Recommended Practice.

COUPLER CONTOUR. STANDARD.

Sheet M. M. 17.

In 1913 the coupler contour lines adopted by the M. C. B. Association in 1903 were adopted as Standard of this Association.

WORN AND DISTORTED COUPLER CONTOUR GAUGE. STANDARD.

Sheet M. M. 17.

In 1913 a worn and distorted coupler contour gauge was adopted as Standard.

SPECIFICATION FOR BOILER AND FIRE-BOX STEEL. — STANDARD.

MADE BY THE OPEN HEARTH PROCESS.

STANDARD.

Adopted in 1894. Revised 1904. Revised 1915.

SPECIFICATIONS FOR BOILER AND FIRE-BOX STEEL FOR LOCOMOTIVE EQUIPMENT.

1. **SCOPE.**—These specifications cover two grades of boiler steel and shall be designated as flange steel and fire-box steel.

I. MANUFACTURE.

2. **PROCESS.**—The steel shall be made by the open-hearth process.

II. Chemical Properties and Tests.

3. CHEMICAL COMPOSITION.—The steel shall conform to the following requirements as to chemical composition:

	Flange.	Fire-box.
Carbon	....	0.12-0.25 per cent
Manganese	0.30-0.60 per cent	0.30-0.50 per cent
Phosphorus, not over	acid 0.05 per cent	0.04 per cent
	basic 0.04 per cent	0.035 per cent
Sulphur, not over	0.05 per cent	0.04 per cent
Copper, not over	....	0.05 per cent

4. **LADLE ANALYSIS.**—An analysis shall be made by the manufacturer from a test ingot taken during the pouring of each melt, a copy of which shall be given to the purchaser or his representative. This analysis shall conform to the requirements specified in Section 3.

5. **CHECK ANALYSIS.**—Analysis may be made by the purchaser from a broken tension test specimen representing each plate as rolled, which shall conform to the requirements specified in Section 3.

III. Physical Properties and Tests.

6. (a) The steel shall conform to the following requirements as to tensile properties:

Tensile strength lb. per sq. in.	55 000-65 000	52 000-62 000
Yield point lb. per sq. in.	0.5 tens. str.	0.5 tens. str.
Elongation in 8 in. min. per cent	$\frac{1\,500\,000}{\text{Tens. str.}}$	$\frac{1\,500\,000}{\text{Tens. str.}}$

(b) The yield point shall be determined by the drop of the beam of the testing machine.

7. **MODIFICATION IN ELONGATION.**—For material over ¾ in. in thickness a deduction of 0.5 from the percentages of elongation specified in Section 6 (a) shall be made for each increase of ⅛ in. thickness above ¾ in. to a minimum of 20 per cent.

8. **BEND TESTS.**—(a) Cold-bend Tests.—The test specimen shall bend cold through 180 deg. without cracking on the outside of the bent portion as follows: For material 1 in. or under in thickness, flat on itself, and for material over 1 in. in thickness, around a pin the diameter of which is equal to the thickness of the specimen.

(b) Quench-bend Tests.—The test specimen, when heated to a light cherry red, as seen in the dark (not less than 1200° F.), and quenched at once in water, the temperature of which is between 80 and 90° F., shall bend through 180 deg. without cracking on the outside of the

bent portion as follows: For material 1 in. or under in thickness, flat on itself, and for material over 1 in. in thickness, around a pin the diameter of which is equal to the thickness of the specimen.

9. **HOMOGENEITY TESTS.**—A sample taken from a broken tension test specimen shall not show any single seam or cavity more than ¼ in. long, in either of the three fractures obtained in the test for homogeneity, which shall be made as follows: The specimen shall be either nicked with a chisel or grooved on a machine, transversely, about 1/16 in. deep, in three places about two inches apart. The first groove shall be made 2 in. from the square end; each succeeding groove shall be made on the opposite side from the preceding one. The specimen shall then be firmly held in a vise, with the first groove about one-fourth inch above the jaws and the projecting end broken off with light blows of a hammer, the bending being away from the groove. The specimen shall be broken at the other two grooves in the same manner. The object of this test is to open and render visible to the eye any seams due to failure of weld or to interposed foreign matter, or any cavities due to gas bubbles in the ingot. One side of each fracture shall be examined and the length of the seams and cavities determined, a pocket lens being used if necessary.

10. **TEST SPECIMENS.**—Tension and bend test specimens shall be taken from the finished rolled material. They shall be of the full thickness of material as rolled, and shall be machined to the form and dimensions shown in Figure 1, except that bend test specimens may be machined with both edges parallel.

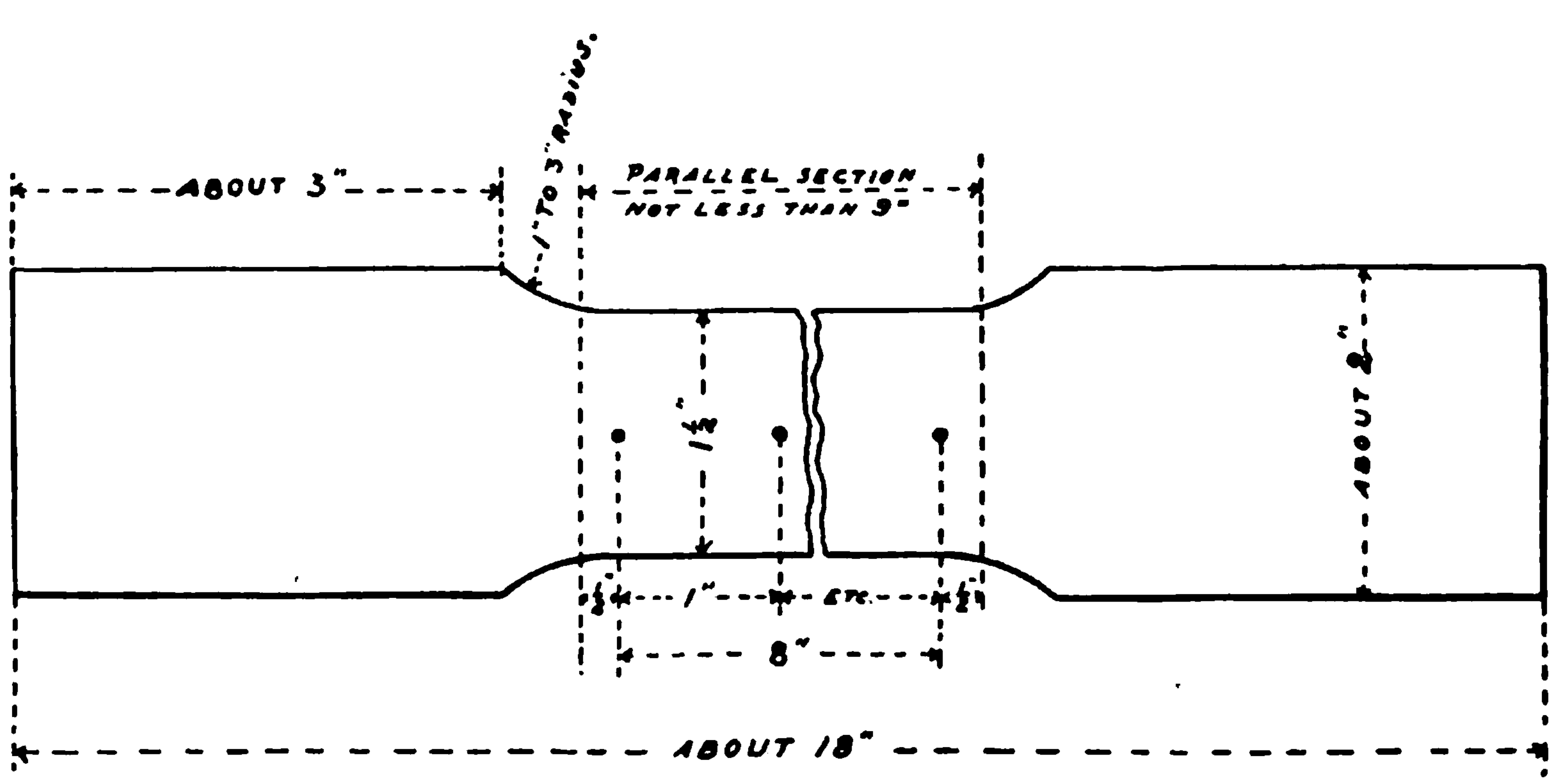


FIG. 1.

11. **NUMBER OF TESTS.**—One tension, one cold-bend and one quench-bend test shall be made from each plate as rolled and in addition

one homogeneity test shall be made from each plate made into fire-box material.

(b) If any test specimen shows defective machining or develops flaws, it may be discarded and another specimen substituted.

(c) If the percentage of elongation of any test specimen is less than that specified in Section 7, and any part of the fracture is outside the middle third of the gaged length, as indicated by the scribe scratches marked on the specimen before testing, a retest shall be allowed.

IV. Permissible Variation in Weight and Gage.

12. **GAGE.**— The thickness of each plate shall not vary more than 0.01 in. under that ordered.

13. **WEIGHT.**—An excess over the nominal weight corresponding to the dimensions on the order shall be allowed for each plate, if not more than that shown in the following table, 1 cu. in. rolled steel being assumed to weigh 0.2833 lb.

Thickness Ordered. In.	Nominal Weight Lb. per sq. ft.	Allowable excess (expressed as percentage nominal weight). For width of Plate, as follows:						
		Under 50 in.	50 to 70 in. excl.	70 in. or over.	Under 75 in.	75 to 100 in. excl.	100 to 115 in. excl.	115 in. and over.
$\frac{1}{8}$ to $\frac{5}{32}$	5.10 to 6.37	10	15	20	......	......	......	......
$\frac{5}{32}$ to $\frac{3}{16}$	6.37 to 7.66	8.5	12.5	17	......	......	......	......
$\frac{3}{16}$ to $\frac{1}{4}$	7.65 to 12.20	7	10	15	......	......	......	......
$\frac{1}{4}$	10.20	......	......	......	10	14	18	......
$\frac{5}{16}$	12.75	......	......	......	8	12	16	......
$\frac{3}{8}$	15.30	......	......	......	7	10	13	17
$\frac{7}{16}$	17 85	......	......	......	6	......	10	13
$\frac{1}{2}$	20.40	......	......	......	5	7	9	12
$\frac{9}{16}$	22 95	......	......	......	4.5	6.5	8 5	11
$\frac{5}{8}$	25.50	......	......	......	4	6	8	10
Over $\frac{5}{8}$	....	......	......	......	3.5	5	6.5	9

V. Finish.

14. **FINISH.**—The finished material shall be free from injurious defects and shall have a workmanlike finish.

VI. Marking.

15. **MARKING.**— The name or brand of the manufacturer, melt and slab number and lowest tensile strength for its grade specified in

Section 6 (a) shall be legibly stamped on each sheet or piece. The melt and slat shall be legibly stamped on each test specimen.

VII. Inspection and Rejection.

16. **INSPECTION.**— The inspector representing the purchaser shall have free entry at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the material ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. All tests (except check analysis) and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

17. **REJECTION.**—(a) Unless otherwise specified, any rejection based on tests made in accordance with Section 5 shall be reported within five working days from receipt of samples.

(b) Material which shows injurious defects subsequent to its acceptance at the manufacturer's works will be rejected, and the manufacturer shall be notified.

18. **REHEARING.**— Samples tested in accordance with Section 5, which represent rejected material, shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with results of the tests, the manufacturer may make claim for rehearing within that time.

SPECIFICATIONS FOR IRON LOCOMOTIVE BOILER TUBES.

STANDARD.

Adopted in 1894. Revised June, 1904.

1. Tubes are to be made of knobbled, hammered charcoal iron, lap-welded.

2. Tubes must be of uniform thickness throughout, except at weld, where an additional thickness of .015 will be allowed. They must be circular within .02 inch, and the mean diameter must be within .015 inch of the size ordered. They must be within .01 inch of the thickness specified and not less than the length ordered, but may exceed this by .125 inch.

3. The minimum weights for tubes of various diameters and thicknesses are given in the following table:

Outside Diameter.	Nominal B. W. G.	Thickness M. M. G.	Minimum weight per foot.
		Inches.	Lbs.
1¾ inch	No. 13	.095	1.65
	" 12	.110	1.89
	" 11	.125	2.07
	" 10	.135	2.29
2 inch	" 13	.095	1.91
	" 12	.110	2.17
	" 11	.125	2.38
	" 10	.135	2.64
2¼ inch	" 13	095	2.16
	" 12	.110	2.46
	" 11	125	2.70
	" 10	.135	2.99
2½ inch	" 12	.110	2.73
	" 11	.125	3.02
	" 10	.135	3.37

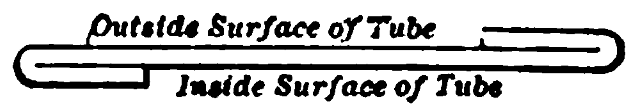
SURFACE INSPECTION.

4. Tubes must have a smooth surface, free from all laminations, cracks, blisters, pits and imperfect welds. They must be free from bends, kinks and buckles, and from evidence of unequal contraction in cooling or injury in manipulation.

PHYSICAL TESTS.

5. Bending Tests.— Strips ½ inch in width by 6 inches in length, planed lengthwise from tubes, after having been heated to a cherry red and quenched in water at 80° F., shall bend in opposite directions at each end, as

shown in sketch below, without cracks or flaws, and when nicked and broken by slight blows, these strips must show a fracture wholly fibrous.



6. Expanding Test.— Sections of tubes 12 inches long shall be heated a length of 5 inches to a bright cherry red in daylight and then placed in a vertical position and a smooth taper steel pin at blue heat will be driven into the end of the tube by light blows of a 10-pound hammer. Under this test the tube must stretch to 1⅛ times its original diameter without splitting or cracking. The pin used shall be of tool steel tapered 1½ inches to the foot. In making this test, care must be taken to see that the end of the tube is smoothly trimmed.

7. One tube is to be tested, as required in paragraphs 5 and 6, in each lot of 250 tubes or less.

8. Crushing Test.— A section of tube 2½ inches long, when placed vertically on the anvil of a steam hammer and subjected to a series of light blows, must crush to a height of 1⅛ inches without splitting in either direction and without cracking or bending at weld.

9. Hydraulic Test.— Before shipping, each tube must be tested by manufacturer to 500 pounds per square inch, and each tube must be plainly marked in the middle: "Knobbled charcoal, tested to 500 pounds pressure."

10. In addition to the above tests, tubes which, when inserted into boilers, split or break while being expanded or beaded, and also individual tubes which fail to pass surface inspection will be rejected and returned to the makers at their expense.

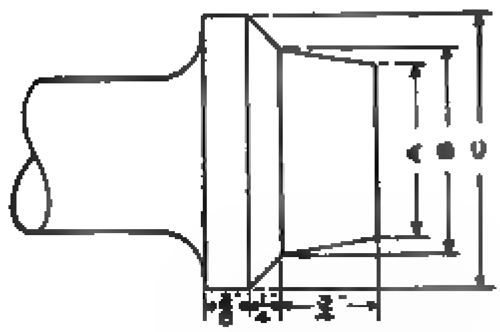
11. Etching Test.— In case of doubt as to the quality of material, the following test shall be made to detect the presence of steel. A section of tube, turned or ground to a perfectly true surface on the end, will be polished free from dirt or cracks, and the end of the tube will be suspended in a bath of nine parts water, three parts sulphuric acid and one part hydrochloric acid. The bath will be prepared by placing water in a porcelain dish, adding the sulphuric and then the hydrochloric acid. The chemical action must be allowed to continue until the soft parts are sufficiently dissolved so that the iron tube will show a decided ridged surface, with the weld very distinct, while the steel tube will show a homogeneous surface.

SPECIFICATION FOR LAP-WELDED AND SEAMLESS STEEL BOILER TUBES, SAFE ENDS AND ARCH TUBES.

SPECIFICATIONS FOR LAP-WELDED AND SEAMLESS STEEL BOILER TUBES, SAFE ENDS, AND ARCH TUBES. STANDARD.

Specifications for seamless, cold-drawn steel locomotive boiler tubes were adopted in 1904. In 1913 they were revised and arranged to include lap-welded and seamless steel boiler tubes, safe ends and arch tubes, as follows:

FLARING TOOL.



A. O.S. DIA OF FLUE LESS [illegible]"
B. " " " " [illegible]"
C. " " " " PLUS [illegible]"

DIE BLOCK.

A. O.S. DIA OF FLUE PLUS [illegible]"

I. MANUFACTURE.

1. The steel shall be made by the open-hearth process.

II. CHEMICAL PROPERTIES AND TESTS.

2. The steel shall conform to the following requirements as to chemical composition:

Carbon	0.08 — 0.18 per cent
Manganese	0.30 — 0.50 per cent
Phosphorus	not over 0.04 per cent
Sulphur	not over 0.045 per cent

3. (a) Analyses of two tubes in each lot of 250 or less may be made by the purchaser, which shall conform to the requirements specified in Section 2. Drillings for analyses shall be taken from several points around each tube.

(b) If the analysis of only one tube does not conform to the requirements specified, analyses of two additional tubes from the same lot shall be made, each of which shall conform to the requirements specified.

III. PHYSICAL PROPERTIES AND TESTS.

4. (a) A test specimen not less than 4 inches in length shall have a flange turned over at right angles to the body of the tubes without showing cracks or flaws. This flange as measured from the outside of the tube shall be ⅜ inch wide for tubes 2½ inches or less outside diameter, and ½ inch wide for tubes larger than 2½ inches outside diameter.

(b) In making the flange test, the flaring tool and die block as shown should be used.

5. A test specimen 4 inches in length shall stand hammering flat until the inside walls are in contact, without cracking at the edges or elsewhere. For lap-welded tubes, care should be taken that the weld is not located at the point of maximum bending.

6. A test specimen 2½ inches in length shall stand crushing longitudinally until the outside folds of metal are in contact, without showing cracks or flaws.

7. Tubes under 5 inches in diameter shall stand an internal hydraulic pressure of 1,000 pounds per square inch, and tubes 5 inches in diameter or over an internal hydraulic pressure of 800 pounds per square inch.

8. (a) Test specimens shall consist of sections cut from tubes selected by the inspector representing the purchaser from the lot offered for shipment. They shall be smooth on the ends and free from burrs.

(b) All specimens shall be tested cold.

9. One flange, one flattening and one crush test shall be made from each of two tubes in each lot of 250 or less. Each tube shall be subjected to the hydraulic test.

10. If the results of the physical tests of only one tube from any lot do not conform to the requirements specified in Sections 4, 5 or 6, retests of two additional tubes from the same lot shall be made, each of which shall conform to the requirements specified.

IV. STANDARD WEIGHTS.

11. The standard weights for tubes of various outside diameters and thicknesses are as follows:

Outside Diameter Inches.	Thickness (Inches).						
	.095 Pounds.	0.110 Pounds.	0.125 Pounds.	0.135 Pounds.	0.150 Pounds.	0.165 Pounds.	0.180 Pounds.
1.75....	1.68	1.93	2.17	2.33	2.56	....	....
2.00....	1.93	2.22	2.50	2.69	2.96	....	....
2.25....	2.19	2.51	2.84	3.05	3.36	....	....
2.50....	2.44	2.81	3.17	3.41	3.76	4.11	4.46
3.00....	....	3.40	3.84	4.13	4.57	5.00	5.42
3.50....	....	....	4.51	4.85	5.37	5.88	6.38
4.00....	....	....	....	5.57	6.17	6.76	7.34
4.50....	....	....	....	....	6.97	7.64	8.30
5.00....	....	....	....	....	7.77	8.52	9.27
5.25....	....	....	....	....	8.17	8.96	9.75
5.375...	....	....	....	....	8.37	9.18	9.99
5.50....	....	....	....	....	8.57	9.40	10.23
6.00....	....	....	....	....	9.37	10.28	11.19

12. The weight of the tubes shall not vary more than 5 per cent from that specified in Section 11.

V. WORKMANSHIP AND FINISH.

13. (a) The finished tubes shall be circular within 0.02 inch, and the mean outside diameter shall not vary more than 0.015 inch from the size ordered. The thickness of any point shall not vary more than 10 per cent from that specified. The length shall not be less, but may be 0.125 inch more than that ordered.

14. The finished tubes shall be free from injurious defects and shall have a workmanlike finish. They shall be free from kinks, bends and buckles.

VI. MARKING.

15. The name or brand of the manufacturer and "Tested at 1,000 pounds" for tubes under 5 inches in diameter, or "Tested at 800 pounds" for tubes 5 inches in diameter or over, shall be legibly stenciled in white on each tube.

VII. INSPECTION AND REJECTION.

16. The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the tubes ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the tubes are being furnished in accordance with these specifications. All tests except check analyses and inspection shall be made at the place of manufacture prior to shipment unless otherwise specified, and are to be so conducted as not to interfere unnecessarily with the operation of the works.

17. (a) Tubes when inserted in the boiler shall stand expanding and beading without showing cracks or flaws, or opening at the weld. Tubes which fail in this manner will be rejected and the manufacturer shall be notified.

(b) Unless otherwise specified, any rejection based on tests made in accordance with Section 3 shall be reported within five working days from the receipt of samples.

18. Samples tested in accordance with Section 3, which represents rejected tubes, shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the test the manufacturer may make claim for a rehearing within that time.

SPECIFICATION FOR ANNEALED AND UNANNEALED CARBON STEEL AXLES.

SHAFTS AND OTHER FORGINGS FOR LOCOMOTIVES. STANDARD.

Adopted as Standard in 1905. Revised in 1915.

Specifications for Annealed and Unannealed Carbon Steel Axles, Shafts and Other Forgings for Locomotives.

1. **BASIS OF PURCHASE.**—(a) These specifications cover annealed and unannealed carbon steel driving axles, engine and trailer truck axles, main and side rods, piston rods, crank pins and miscellaneous forgings.

(b) The manufacturer may, at his option, furnish annealed forgings when unannealed forgings are specified by the purchaser, provided they conform to the requirements specified for unannealed forgings.

I. Manufacture.

2. **PROCESS.**— The steel may be made by the open-hearth or other process approved by the purchaser.

3. **DISCARD.**—A sufficient discard shall be made from each ingot to secure freedom from injurious piping and undue segregation.

4. **PROLONGATION FOR TEST.**— The manufacturer and the purchaser shall agree upon forgings on which a prolongation for test purposes shall be provided.

5. **HEAT TREATMENT.**— For annealing, the forgings shall be allowed to become cold after forging. They shall then be uniformly reheated to the proper temperature to refine the grain (a group thus reheated being known as an annealing charge) and allowed to cool uniformly.

II. Chemical Properties and Tests.

6. **CHEMICAL COMPOSITION.**— The steel shall conform to the following requirements as to chemical composition:

Carbon	0.38-0.52 per cent
Manganese	0.40-0.75 per cent
Phosphorus, not over..................	0.05 per cent
Sulphur, not over......................	0.05 per cent

7. **LADLE ANALYSIS.**—An analysis shall be made by the manufacturer from a test ingot taken during the pouring of each melt, a copy of which shall be given to the purchaser or his representative. This analysis shall conform to the requirements specified in Section 6.

8. **CHECK ANALYSIS.**— Analysis may be made by the purchaser from a forging representing each melt, which shall conform to the requirements specified in Section 6. Drillings for analysis may be taken from the forging or from a full-sized prolongation of the same, at any point midway between the center and surface, or turnings may be taken from a test specimen.

III. Physical Properties and Tests.

9. **TENSION TESTS.**—(a) The forgings shall conform to the following minimum requirements as to tensile properties:

For forgings whose maximum outside diameter or overall thickness is not over 12 in. when unannealed and not over 20 in. when annealed.

UNANNEALED.

Size, Outside Diameter or Overall Thickness.	Tens. Str. lb. per sq. in.	Yield point lb. per sq. in.	Elongation in 2 in per cent		Reduction of area per cent	
			Inverse Ratio.	Not Under.	Inverse Ratio.	Not Under.
Not over 8 in.............	75 000	0.5 tens. str.	1 600 000 / tens. str.	18	2 200 000 / tens. str.	24
Over 8 to 12 in., inclusive...	75 000	0.5 tens. str.	1 500 000 / tens. str.	17	2 000 000 / tens. str.	22

ANNEALED.

Not over 8 in.	80 000	0.5 tens. str.	$\frac{1\,800\,000}{\text{tens. str.}}$	20	$\frac{2\,800\,000}{\text{tens. str.}}$	32
Over 8 to 12 in., inclusive.	80 000	0.5 tens. str.	$\frac{1\,725\,000}{\text{tens. str.}}$	19	$\frac{2\,640\,000}{\text{tens. str.}}$	30
Over 12 to 20 in., inclusive.	80 000	0.5 tens. str.	$\frac{1\,650\,000}{\text{tens. str.}}$	18	$\frac{2\,400\,000}{\text{tens. str.}}$	28

(b) The classification by size of the forging shall be determined by the specified diameter or thickness which governs the size of the prolongation from which the test specimen is taken.

(c) The yield point shall be determined by the drop of the beam of the testing machine.

(d) Tests of forgings shall be made only after final treatment.

10. **TENSION TEST SPECIMENS.**—(a) Tension test specimens shall be taken from a full-sized prolongation of any forging. For forgings with large ends or collars the prolongation may be of the same cross section as that of the forging back of the large end or collar. Specimens may be taken from the forging itself with a hollow drill, if approved by the purchaser.

(b) The axis of the specimen shall be located at any point midway between the center and the surface of the forging, and shall be parallel to the axis of the forging in the direction in which the metal is most drawn out.

(c) Test specimens shall be of the form and dimensions shown in Figure 1.

11. **NUMBER OF TESTS.**— Unless otherwise specified by the purchaser, tests shall be made as follows:

(a) For unannealed forgings one tension test shall be made from each melt.

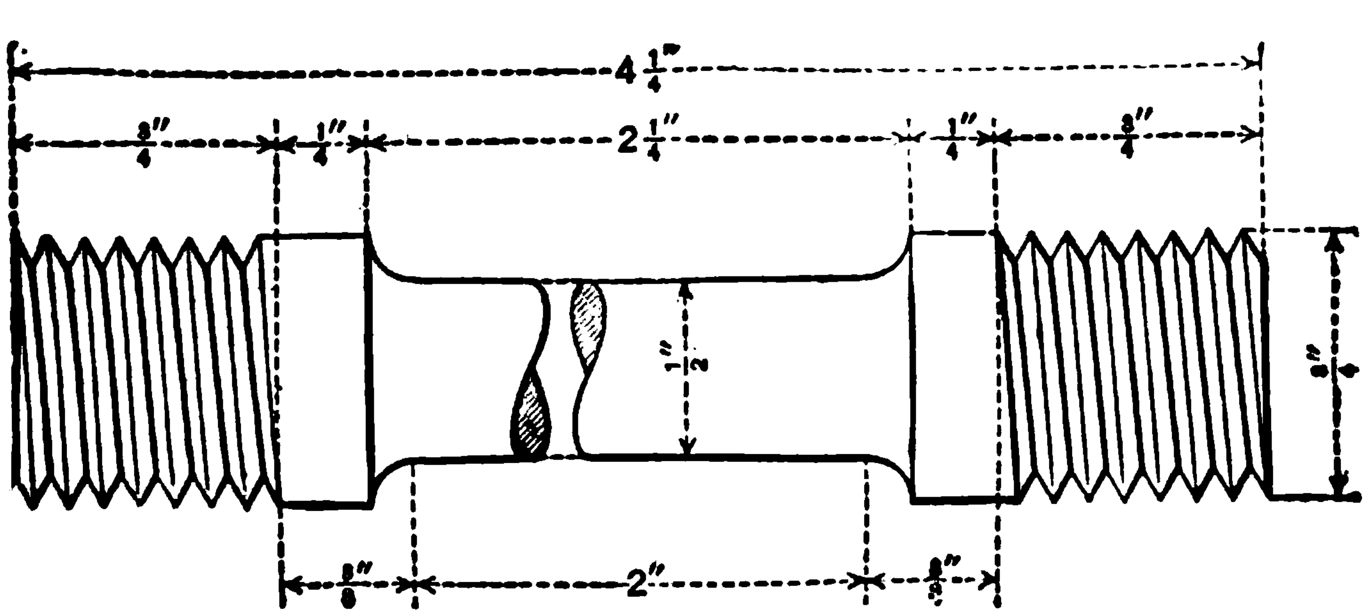


FIG. 1.

(b) For annealed forgings one tension test shall be made from each annealing charge. If more than one melt is represented in an annealing charge, one tension test shall be made from each melt.

(c) If more than one class of forgings by size is represented in any lot, one tension test from a forging of each class by size shall be made as specified in Sections 9 and 10.

(d) If any test specimen shows defective machining or develops flaws, it may be discarded and another substituted.

(e) If the percentage of elongation of any tension test specimen is less than that specified in Section 9 (a), and any part of the fracture is more than ¾ in. from the center of the gage length, as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed.

12. **RETESTS.**—(a) If the results of the physical tests of any test lot do not conform to the requirements specified, the manufacturer may reanneal such lot, but not more than three additional times unless authorized by the purchaser, and retests shall be made as specified in Section 11.

(b) When annealed forgings are specified, if the fracture of any tension test specimen shows over 15 per cent crystalline, a second test shall be made. If the fracture of the second specimen shows over 15 per cent crystalline, the forgings represented by such specimen shall be reannealed.

IV. Workmanship and Finish.

13. **WORKMANSHIP.**— The forgings shall conform to the size and shapes specified by the purchaser. When centered, 60 deg. centers with clearance drilled for points shall be used.

14. **FINISH.**— The forgings shall be free from injurious defects and shall have a workmanlike finish.

V. Marking.

15. **MARKING.**— Identification marks shall be legibly stamped on each forging and on each test specimen. The purchaser shall indicate the location of such identification marks.

VI. Inspection and Rejection.

16. **INSPECTION.**—(a) The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the forgings ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the forgings are being furnished in accordance with these specifications. Tests and inspection at the place of manufacture shall be made prior to shipment.

(b) The purchaser may make the tests to govern the acceptance or rejection of the forgings at his own laboratory or elsewhere; such tests, however, shall be made at the expense of the purchaser.

(c) Tests and inspection shall be so conducted as not to interfere unnecessarily with the operation of the works.

17. **REJECTION.**—(a) Unless otherwise specified, any rejection based on tests made in accordance with Section 16 (b) shall be reported within five working days from receipt of samples.

(b) Forgings which show injurious defects while being finished by the purchaser will be rejected and the manufacturer shall be notified.

18. **REHEARING.**— Samples tested in accordance with Section 16 (b) which represent rejected forgings, shall be preserved for two weeks from the date of test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.

19. **FREIGHT CHARGES.**—All rejected material will be returned to the manufacturer who shall pay freight charges both ways.

SPECIFICATIONS FOR STEEL BLOOMS AND BILLETS FOR LOCOMOTIVE FORGINGS. STANDARD.

Adopted as Standard in 1905.

MATERIAL.

1. Open-hearth steel.

PHYSICAL REQUIREMENTS.

2. Grade "A":
   Tensile strength, 70,000 lbs. per square inch.
   Elongation in two inches, 20 per cent.

3. Grade "B":
   Tensile strength, 80,000 lbs. per square inch.
   Elongation in two inches, 17 per cent.

CHEMICAL ANALYSIS.

4. Grade "A":

Carbon	.25 to .40 per cent.
Phosphorus, not to exceed	.06 per cent.
Sulphur, not to exceed	.06 per cent.
Manganese, not to exceed	.60 per cent.

5. Grade "B":

Carbon	.35 to .50 per cent.
Phosphorus, not to exceed	.05 per cent.
Sulphur, not to exceed	.05 per cent.
Manganese, not to exceed	.60 per cent.

TESTS.

6. One test per melt will be required, the test specimen to be cut cold from the bloom, parallel to its axis and half-way between the center and the outside. The standard turned test specimen, ½ inch in diameter and 2 inches gauge length, shall be used to determine the physical properties. (See Fig. 1.) Drillings or turnings from the tensile specimen shall be used to determine the chemical properties.

STAMPING AND MARKING.

7. Each bloom or billet must have heat number and manufacturer's name plainly stamped on one end, with stamps not less than ⅜ inch, and have order number plainly marked with white lead.

INSPECTION.

8. Blooms and billets must be free from checks, pipes and surface defects. Any blooms or billets chipped to a depth greater than ½ inch will be rejected.

9. Any billet or bloom failing to meet the above requirements will be rejected and held subject to disposal by manufacturers.

10. Inspector to have the privilege of taking drillings from the center of the top bloom or billet of the ingot in order to determine the amount of segregation.

Grade "A" is intended for rod straps and miscellaneous forgings.

Grade "B" is intended for driving and truck axles, connecting rods, crank pins and guides.

SPECIFICATIONS FOR FOUNDRY PIG IRON.

STANDARD.

At the convention of 1906 specifications for foundry pig iron were proposed, and on reference to letter ballot were adopted as standard. They are as follows:

The material desired under this specification is an open-grain foundry pig conforming to and graded by the following detail specifications:

Combined carbon	.40 to .70 per cent.
Manganese	.40 to .80 per cent.
Phosphorus	.40 to .80 per cent.
Sulphur, not over	.06 per cent.

The grades are determined by the amount of silicon, in accordance with the attached schedule:

Grade No. 1, silicon	3.00 to 2.50 per cent.
Grade No. 2, silicon	2.50 to 2.00 per cent.
Grade No. 3, silicon	2.00 to 1.50 per cent.
Grade No. 4, silicon	1.50 to 1.00 per cent.

Each carload, or its equivalent, shall be considered as a unit. At least one pig shall be selected at random for each four tons of every carload and so as to fairly represent it.

Drillings shall be taken so as to fairly represent the fracture surface of each pig, and the sample analyzed shall consist of an equal quantity of drillings from each pig, well mixed and ground before analysis.

In case of disagreement between buyer and seller, an independent analyst, to be mutually agreed upon, shall be engaged to sample and analyze the iron. In this event one pig shall be taken to represent every two tons.

The cost of this sampling and analysis shall be borne by the buyer if the shipment is proved up to specifications, and by the seller if otherwise.

SPECIFICATIONS FOR LOCOMOTIVE CYLINDER CASTINGS, CYLINDER BUSHINGS, CYLINDER HEADS, STEAM CHESTS, VALVE BUSHINGS AND PACKING RINGS. STANDARD.

At the convention of 1906 the specifications as above were adopted as Standard. Revised 1915.

I. Manufacture.

1. **PROCESS.**— Locomotive cylinders, cylinder bushings, cylinder heads, steam chests, valve bushings and packing rings shall be made from good quality close-grained gray iron cast in a dry mold.

II. Chemical Properties and Tests.

2. **CHEMICAL COMPOSITION.**— Drillings taken from the fractured end of the transverse test bars shall conform to the following limits in chemical composition:

Phosphorus, not over	0.90 per cent
Sulphur, not over	0.12 per cent
Manganese, not over	0.70 per cent
Silicon, not over	1.60 per cent

3. **CHECK ANALYSIS.**—A check analysis of drillings taken from the transverse test bar may be made by the purchaser, and shall conform to the requirements specified in Section 2.

III. Physical Properties and Tests.

4. **TRANSVERSE TESTS.**—When placed horizontally upon supports 12 in. apart and tested under a centrally applied load, the arbitration test bars, specified in Section 6 (a), shall show an average transverse strength of not less than 3200 lb. and an average deflection of not less than 0.09 in. The rate of application of the load shall be from 20 to 40 sec. for a deflection of 0.10 in.

5. **CHILL TEST.**— Before pouring, a sample of the iron shall be

taken and chilled in a cast-iron mold, as specified in Section 6 (b). The sample shall be allowed to cool in the mold until it is dark red or almost black, when it may be knocked out and quenched in water. The sample, on being broken, must show a close-grained gray iron, with a well defined border of white iron at the bottom of the fracture. The depth of the white iron must not be less than $\frac{1}{16}$ in. as measured at the center line.

6. **MOLDS FOR TEST SPECIMENS.**—(a) ARBITRATION BAR.—The mold for the bars is shown in Figure 1. The bottom of the bar is $\frac{1}{16}$ in. smaller in diameter than the top, to allow for draft and for strain of pouring. The pattern shall not be rapped before withdrawing. The flask is to be rammed up with green molding sand, a little damper than usual, well mixed and put through a No. 8 sieve, with a mixture of 1 to 12 bituminous facing. The mold shall be rammed evenly and fairly hard, thoroughly dried and not cast until it is cold. The test bar should not be removed from the mold until cold enough to be handled. It shall not be rumpled or otherwise treated, being simply bushed off before testing.

(b) CHILL TEST.—The form and dimensions of the mold shall be in accordance with Figure 2.

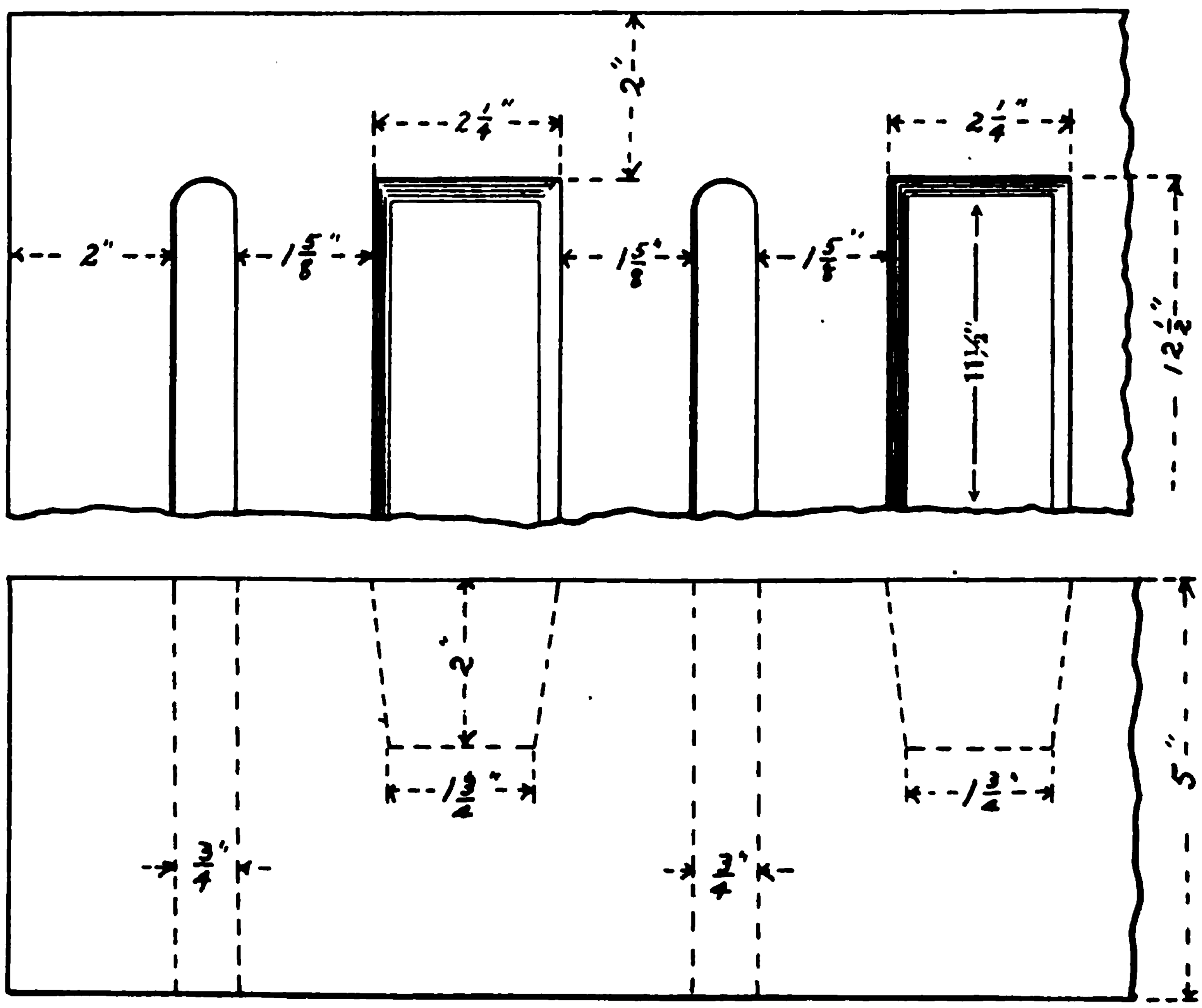


FIG. 2.—MOLD FOR CHILL TEST SPECIMEN.

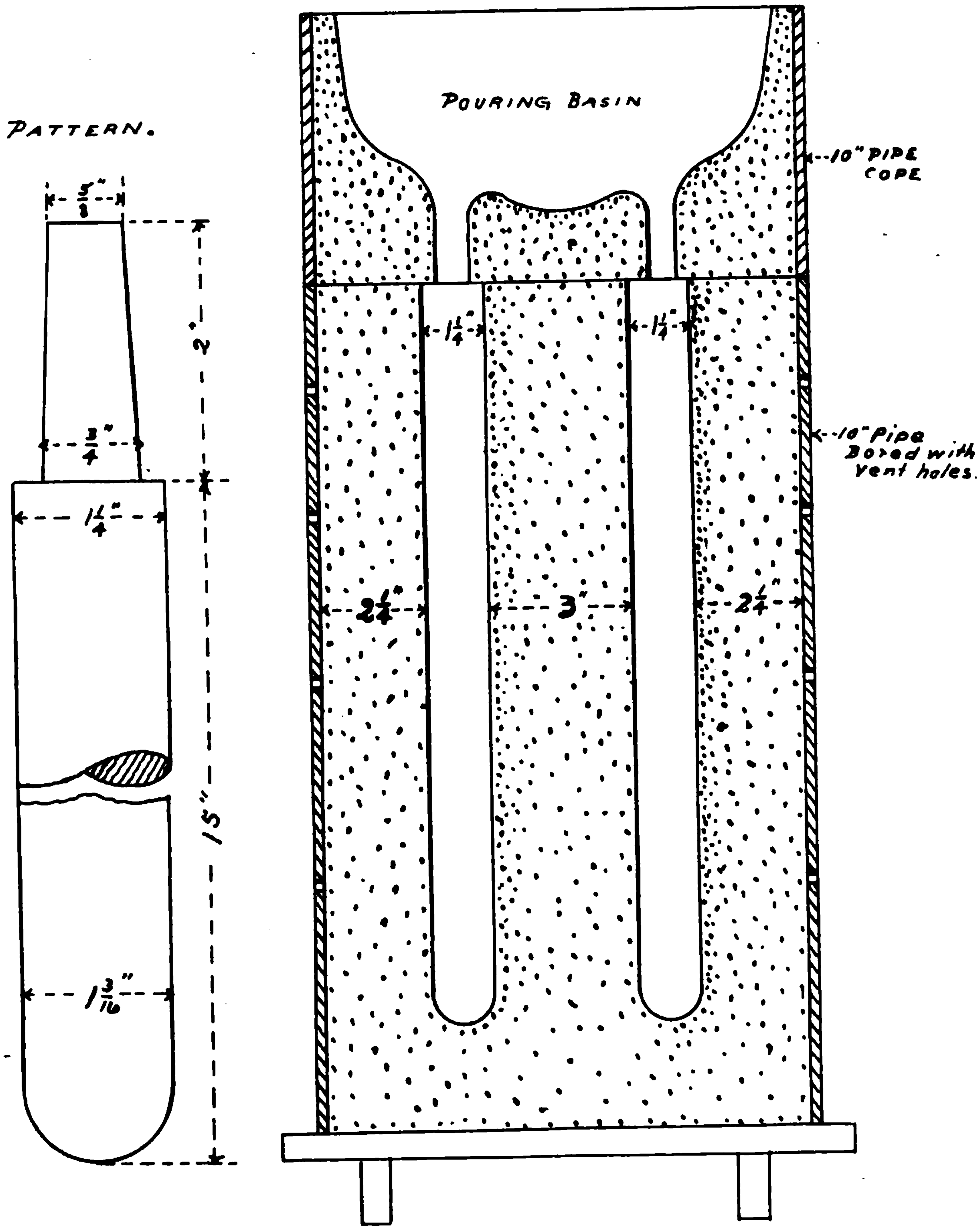


FIG. 1.—MOLD FOR ARBITRATION TEST BAR.

7. **NUMBER OF TESTS.**—(a) Two arbitration test bars, cast as specified in Section 6 (a), shall be poured from each ladle of metal used for one or more cylinders.

(b) One chill test, cast as specified in Section 6 (b), shall be poured from each ladle of metal used for one or more cylinders. The chill specimens may be cast in adjacent molds, but in such cases a space must be provided between the molds. (See Fig. 2.)

IV. Workmanship and Finish.

8. **CHARACTER OF CASTINGS.**— Cylinders shall be smooth, well cleaned, free from shrinkage cracks and from other defects sufficiently extensive to impair the value of the castings, and must finish to blue-print size.

V. Marking.

9. **MARKING.**— Each cylinder shall have cast on it, in raised letters, marks designating the maker, the date of casting, the serial and pattern numbers and other marks specified by the purchaser.

VI. Inspection and Rejection.

10. **INSPECTION.**—(a) The purchaser, or his inspector, shall be given a reasonable opportunity to enable him to witness the pouring of the cylinders and test specimens, as well as to be present when physical tests are made.

(b) In case the inspector is not present to witness the pouring of the castings and test specimens, the manufacturer will make all tests required by the specification, and, upon demand, will furnish the purchaser with a copy of the results of his tests, and will hold the transverse and chill specimens subject to examination by the inspector. The tests made by the manufacturer shall be considered final.

(c) All physical tests and inspection shall be made at the place of manufacture.

11. **REJECTION.**— Unless otherwise specified, any rejection based on tests made in accordance with Section 3 shall be reported within five days from the receipt of samples.

SPECIFICATIONS FOR CAST-STEEL LOCOMOTIVE FRAMES.

RECOMMENDED PRACTICE.

In 1913 specifications for cast-steel locomotive frames were adopted as Recommended Practice. Revised 1915 as follows:

1. **BASIS OF PURCHASE.**— These specifications cover steel castings for locomotive frames, wheel centers and miscellaneous castings.

I. Manufacture.

2. **PROCESS.**— The steel may be made by the open-hearth, crucible or other process approved by the purchaser.

3. **HEAT TREATMENT.**— Castings shall be allowed to become cold. They shall then be uniformly reheated to the proper temperature to refine the grain (a group thus reheated being known as an annealing charge) and allowed to cool uniformly and slowly. If, in the opinion of the purchaser or his representative, a casting is not properly annealed, he may at his option require the casting to be reannealed.

II. Chemical Properties and Tests.

4. **CHEMICAL COMPOSITION.**— The steel shall conform to the following requirements as to chemical composition:

Table I.

	Frames.		Wheel Centers and Miscellaneous Castings.
	Grade A.	*Grade B.	
Carbon	0.25-0.37 per cent.	0.37-0.50 per cent.	0.22-0.35 per cent.
Manganese	0.40-0.75 "	0.40-0.75 "	0.40-0.75 "
Phosphorus, not over	0.05 "	0.05 "	0.05 "
Sulphur, not over	0.05 "	0.05 "	0.05 "

* When high carbon steel frames are specified this grade shall be used.

5. **LADLE ANALYSIS.**— An analysis shall be made by the manufacturer from a test ingot taken during the pouring of each melt, a copy of which shall be given to the purchaser or his representative. This analysis shall conform to the requirements specified in Section 4.

6. **CHECK ANALYSIS.**—Analysis may be made by the purchaser from a test piece and also from any casting selected at random, and shall conform to the requirements specified in Section 4.

III. Physical Properties and Tests.

7. **TENSION TESTS.**—(a) The steel shall conform to the following minimum requirements as to tensile properties:

	Frames.		Wheel Centers and Miscellaneous Castings.
	Grade A.	Grade B.	
Tensile strength, lb. per. sq. in.	65 000	75 000	60 000
Elastic limit, lb. per sq. in.	30 000	35 000	25 000
Elongation in 2 in., min. per cent	20	15	22
Reduction of area, min. per cent	28	22	30

(b) The elastic limit shall be determined by an extensometer.

8. **ALTERNATIVE TESTS TO DESTRUCTION.**— In the case of small or unimportant castings, a test to destruction on three castings from a lot may be substituted for the tension tests. This test shall show the material to be ductile, free from injurious defects and suitable for the purpose intended.

9. **TEST SPECIMEN.**—(a) Sufficient test bars shall be furnished from which test specimens required in Section 7 may be selected. They shall be attached to castings weighing 500 lb. or over, when the design of the castings will permit. If the castings weigh less than 500 lb., or are of such a design that test bars can not be attached, two test bars shall be cast to represent each melt; or the quality of the casting shall be determined by testing to destruction as specified in Section 8. All test bars shall be annealed with the castings they represent.

(b) The manufacturer and the purchaser shall agree whether test bars can be attached to castings, on the location of the bars on the castings, on the castings to which bars are attached, and on the method of casting unattached bars.

(c) If the purchaser, or his representative, so desires, a test specimen may be cut from a finished casting, such casting so destroyed shall be paid for by the purchaser.

(d) The purchaser shall have the privilege of taking drillings for analysis from a casting, so long as it does not destroy or weaken the casting.

(e) Tension test specimens shall be of the form and dimension shown in Figure 1. Annealing coupons shall be located at points agreed upon by the manufacturer and the purchaser.

10. **NUMBER OF TESTS.**— One tension test shall be made from each locomotive frame, and in the case of wheel centers and miscellaneous castings, from an annealing charge, or from each melt if more than one melt is in an annealing charge.

IV. Variation in Weight.

11. **WEIGHT.**—All castings shall come within the maximum and minimum weight, where shown on the prints, and when castings weighing

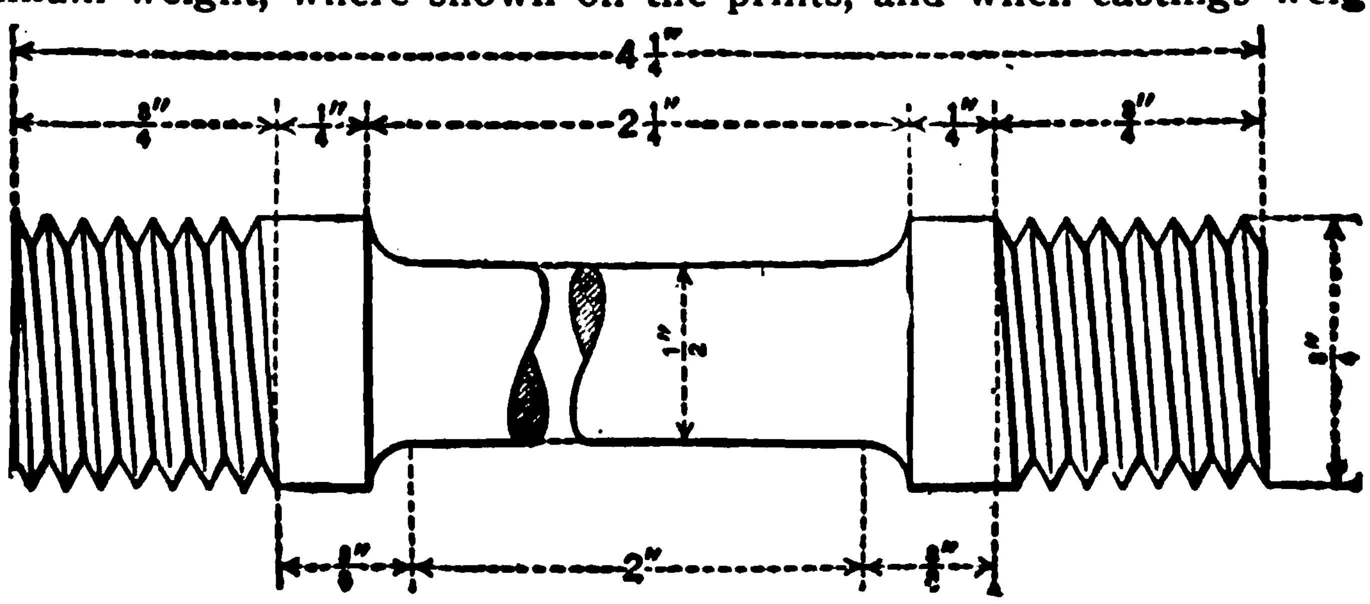


Fig. 1.

more than the allowable maximum weight are presented, such castings shall be accepted at the maximum weight provided they meet all other tests, the excess weight being at the expense of the manufacturer.

V. Workmanship and Finish.

12. **WORKMANSHIP.**— The castings shall substantially conform to the sizes and shapes shown on prints, and shall be made in a workmanlike manner. Where surfaces are machined, the castings shall have the proper allowance for finish.

13. **PATTERNS.**—When patterns are furnished by the purchaser, the manufacturer shall make sure that the allowance for shrinkage in these patterns agrees with his own practice. Under no circumstance shall manufacturers change purchasers' patterns without first obtaining permission.

14. **FINISH.**—(a) The castings shall be free from injurious defects. Castings shall not be painted before inspection. Castings rusted to any extent, or covered with any material to hide defects, will be rejected.

(b) Any castings found with blow holes, cracks, low spots or thin sections filled with cement, Smooth-On or like material, shall be rejected and can not be further considered. Oxy-Acetylene, electric or similar welding will not be permitted, unless authorized by the purchaser or his representative, and then only at locations where the defects will not in any way be detrimental to the strength of the casting, this welding only being granted in order to effect a better appearance of the casting.

VI. Marking.

15. **MARKING.**— The manufacturer's name or identification mark and melt number shall be cast on each casting at such location as shall be agreed upon by the manufacturer and the purchaser.

VII. Inspection and Rejection.

16. **INSPECTION.**—(a) The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the material ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the castings are being furnished in accordance with these specifications. Tests and inspections at the place of manufacture shall be made prior to shipment.

(b) The purchaser may make the tests to govern the acceptance or rejection at his own laboratory or elsewhere. Such tests, however, shall be made at the expense of the purchaser.

(c) Tests and inspection shall be so conducted as not to interfere unnecessarily with the operation of the works.

17. **REJECTION.**—(a) Unless otherwise specified, any rejection based on tests made in accordance with Section 16 (b) shall be reported within five working days from the receipt of samples.

(b) Castings which show any injurious defects or do not conform to the dimensions given on prints shall be rejected.

(c) Castings which show injurious defects while being furnished by the purchaser will be rejected and the manufacturer shall be notified.

18. **REHEARING.**— Samples tested in accordance with Section 16 (b) which represent rejected material, shall be preserved for two weeks from date of test report. In case of dissatisfaction with results of tests, the manufacturer may make a claim for a rehearing within that time.

SPECIFICATIONS FOR QUENCHED AND TEMPERED ALLOY STEEL FORGINGS.

RECOMMENDED PRACTICE.

In 1914 specifications for alloy steel forgings for locomotive construction were adopted as Recommended Practice. Revised in 1915.

1. **BASIS OF PURCHASE.**—(a) These specifications cover the various classes of chrome-nickel and chrome-vanadium alloy steel forgings now commonly used in locomotive construction.

(b) The purposes for which these classes are frequently used are as follows:

CLASS A.— Forgings for main and side rods, straps and piston rods, and all other forgings which are to be machined with milling cutters or complicated forming tools, or when there is an abrupt change in section.

CLASS B.— Forgings for driving and trailer axles, crank pins, plain piston rods, cross-head pins and other forgings not requiring the use of milling cutters or complicated forming tools.

I. MANUFACTURE.

2. **PROCESS.**— The steel may be made by the open-hearth or other process approved by the purchaser.

3. **DISCARD.**—A sufficient discard shall be made from each ingot to secure freedom from injurious piping and undue segregation.

4. **PROLONGATION FOR TEST.**— For test purposes a prolongation shall be left on each forging, unless otherwise specified by the purchaser.

5. **BORING.**—(a) All forgings over 7 in. in diameter shall be bored, unless otherwise specified by the purchaser. The boring shall be done before quenching.

(b) If boring is specified, the diameter of the hole shall be at least 20 per cent of the maximum outside diameter or thickness of the forging, exclusive of collars and flanges.

6. **HEAT TREATMENT.**— For quenching and tempering, the forgings shall be allowed to become cold after forging. They shall then

be uniformly reheated to the proper temperature to refine the grain (a group thus reheated being known as a quenching charge) and quenched in some medium under substantially uniform conditions for each quenching charge. Finally they shall be uniformly reheated to the proper temperature for tempering or "drawing back" (a group thus reheated being known as a tempering charge) and allowed to cool uniformly.

II. Chemical Properties and Tests.

7. **CHEMICAL COMPOSITION.**— The steel shall conform to the following requirements as to chemical composition.

	Chrome Nickel	Chrome Vanadium
Carbon	0.28—0.42 per cent	0.28—0.42 per cent
Manganese	0.40—0.70 per cent	0.40—0.70 per cent
Silicon	0.10—0.30 per cent	....
Phosphorus, not over	0.05 per cent	0.05 per cent
Sulphur, not over	0.05 per cent	0.05 per cent
Chromium	0.60—1.00 per cent	0.75—1.25 per cent
Nickel	1.00—1.50 per cent	....
Vanadium, not under	....	0.15 per cent

8. **LADLE ANALYSIS.**—An analysis shall be made by the manufacturer from a test ingot taken during the pouring of each melt, a copy of which shall be given the purchaser or his representative. This analysis shall conform to the requirements specified in Section 7.

9. **CHECK ANALYSIS.**—(a) An analysis may be made by the purchaser from a forging representing each melt, which shall conform to the requirements specified in Section 7. Drillings for analysis may be taken from a forging, or from a full-sized prolongation of the same, at any point midway between the center and surface of solid forgings, and at any point midway between the inner and outer surfaces of the wall of the bored forgings, or turnings may be taken from a test specimen.

(b) In addition to the complete analysis a phosphorus determination may be made by the purchaser from each tension test specimen, and this determination shall conform to the requirements for phosphorus specified in Section 7.

III. Physical Properties and Tests.

10. **TENSION TESTS.**—(a) The forgings shall conform to the requirements as to tensile properties specified in Table 1.

TABLE No. 1.

For forgings whose maximum diameter or thickness is not over 10 in. when solid.

CLASS A.

	Tens. str. lb. per sq. in.	Elastic limit minimum lb. per sq. in.	Elongation in 2 in. minimum per cent.	Reduction of area minimum per cent.
Main and side rods, straps, piston rods...	90 000 to 110 000	65 000	20	50

CLASS B.

	Tens. str. in lb. per sq. in.	Elastic limit minimum lb. per sq. in.	Elongation in 2 in. minimum per cent.	Reduction of area minimum per cent.
Up to 7 in. diameter or thickness when solid. or 3½-in. max. wall..	100 000 to 120 000	75 000	20	50
7 in. to 10 in. diameter or thickness when solid, or 5-in max. wall..............	100 000 to 120 000	75 000	18	45

(b) The classification by size of the forgings shall be determined by the specified diameter or thickness which governs the size of the prolongation from which the test specimen is taken.

(c) Elastic limit shall be determined by means of an extensometer of a type the equal of the "Berry" strain gage.

(d) Test of forgings shall be made only after final treatment.

(e) The speed of the test machine shall not exceed ⅛ in. per minute until the elastic limit has been reached.

11. **BEND TESTS.**— If specified by the purchaser bend tests shall be made as follows:

(a) For forgings up to 7 in. in diameter or thickness when solid, or 3½-in. maximum wall, the test specimen shall bend cold through 180 deg. on a 1-in. flat mandrel having a rounded edge of ½-in. radius without cracking on the outside of the bent portion.

(b) For forgings 7 in. to 10 in. in diameter or thickness when solid,

or, 5-in. maximum wall, the test specimen shall bend cold through 180 deg. around a 1½-in. flat mandrel having a rounded edge of ¾ in. radius without cracking on the outside of the bent portion.

12. **PROOF TEST.**—(a) Unless otherwise specified by the purchaser, all forgings shall be subjected to an impact proof test. The details of this test shall be agreed upon by the manufacturer and the purchaser.

(b) A recommended test for axles, shafts and similar forgings is as follows: Place the forging upon supports 3 ft. apart mounted on an M. C. B. drop test machine. The forging should then be struck two blows by a tup weighing either 1640 or 2240 lb. falling from heights proportioned according to the following formula and tabulation. Between the first and second blows the forgings shall be turned 90 deg.

Height of drop in feet $= 0.01\ D^3$ for 1640-lb. tup.

Height of drop in feet $= 0.0073\ D^3$ for 2240-lb. tup.

Note.— D = Diameter of shaft or thickness of forging at center in inches.

Table No. 2.

Diameter of Shaft at center, inches.	Height of drop in feet.	
	1 640-lb. tup.	2 240-lb. tup.
5	1 ft. 3 in	0 ft. 11 in
5½	1 ft. 8 in	1 ft. 3 in.
6	2 ft. 2 in	1 ft. 7 in.
6½	2 ft. 9 in	2 ft. 0 in.
7	3 ft. 5 in	2 ft. 6 in.
7½	4 ft. 3 in	3 ft. 1 in.
8	5 ft. 1 in	3 ft. 9 in.
8½	6 ft. 2 in	4 ft. 6 in.
9	7 ft. 3 in	5 ft. 4 in.
9½	8 ft. 7 in	6 ft. 3 in.
10	10 ft. 0 in	7 ft. 4 in.
10½	11 ft. 7 in	8 ft. 5 in.
11	13 ft. 4 in	9 ft. 9 in.
11½	15 ft. 3 in	11 ft. 3 in.
12	17 ft. 3 in	12 ft. 7 in.
12½	19 ft. 5 in	14 ft. 3 in.
13	22 ft. 0 in	16 ft. 0 in.
13½	24 ft. 7 in	18 ft. 0 in.
14	27 ft. 5 in	20 ft. 0 in.
14½	30 ft. 6 in	22 ft. 3 in.
15	33 ft. 9 in	24 ft. 8 in.

Note.— The above heights are to the nearest inch.

13. **TEST SPECIMEN.**—(a) Tension and bend test specimens shall be taken from a full size prolongation of any forging. For forgings with large ends or collars, the prolongation may be of the same cross section as that of the forging back of the large end or collar. Specimens may be taken from the forging itself with a hollow drill, if approved by the purchaser.

(b) The axis of the specimen shall be located at any point midway between the center and surface of solid forgings, and at any point midway between the inner and outer surfaces of the wall of the bored forgings, and shall be parallel to the axis of the forging in the direction in which the metal is most drawn out.

(c) Tension test specimens shall be of the form and dimensions shown in Fig. 1.

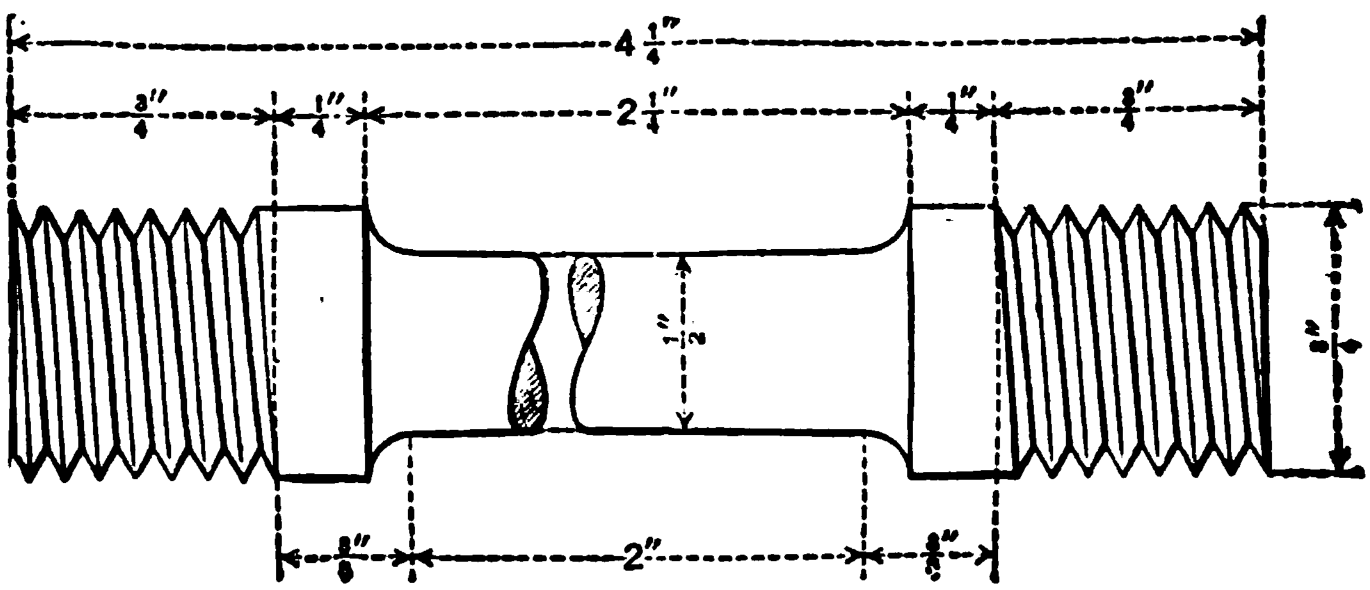


FIG. 1.

(d) Bend test specimens shall be ½ in. square in section with corners rounded to a radius not over 1/16 in. and need not exceed 6 in. in length.

14. **NUMBER OF TESTS.**—(a) One tension, and if specified by the purchaser, one bend test shall be made from each tempering charge. If more than one quenching charge is represented in a tempering charge, one tension, and, if specified, one bend test shall be made from each quenching charge. If more than one melt is represented in a quenching charge, one tension and, if specified, one bend test shall be made from each melt.

(b) If more than one class of forgings by size is represented in any lot, one tension and, if specified, one bend test from a forging of each class by size shall be made as specified in Sections 10, 11 and 13.

(c) If any test specimen shows defective machining or develops flaws, it may be discarded and another specimen substituted.

(d) If the percentage of elongation of any tension test specimen is less than that specified in Section 10 (a) and any part of the fracture is more than ¾ in. from the center of the gage length, as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed.

15. **RETESTS.**—(a) If the fracture of any tension test specimen shows over 15 per cent crystalline, a second test shall be made. If the fracture of the second specimen shows over 15 per cent crystalline, the forgings represented by such specimen shall be retempered or requenched and retempered.

(b) If the results of the physical tests of any lot do not conform to the requirements specified, the manufacturer may retemper or requench and retemper such lot, but not more than three additional times, unless authorized by the purchaser, and retests shall be made as specified in Section 14.

IV. Workmanship and Finish.

16. **WORKMANSHIP.**— The forgings shall conform to the sizes and shapes specified by the purchaser. Axles, shafts and similar forgings, unless otherwise specified, shall be rough turned with an allowance of ⅛ in. on the surface for finishing, except on the collars of axles or other forgings, which shall be left rough forged. In centering 60 deg. centers with clearance drilled for points shall be used.

17. **FINISH.**— The forgings shall be free from injurious defects and shall have a workmanlike finish.

V. Marking.

18. **MARKING.**— Identification marks shall be legibly stamped on each forging and on each test specimen. The purchaser shall indicate the location of such identification marks.

VI. Inspection and Rejection.

19. **INSPECTION.**—(a) The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the forgings ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the forgings are being furnished in accordance with these specifications. Tests and inspections at the place of manufacture shall be made prior to shipment.

(b) The purchaser may make the tests to govern the acceptance or rejection of the forgings in his own laboratory or elsewhere. Such tests, however, shall be made at the expense of the purchaser.

(c) Tests and inspection shall be so conducted as not to interfere with the operation of the works.

20. **REJECTION.**—(a) Unless otherwise specified, any rejection based on tests made in accordance with Section 19 (b) shall be reported within five working days from the receipt of the samples.

(b) Forgings which show injurious defects while being finished by the purchaser will be rejected, and the manufacturer shall be notified.

21. **REHEARING.**— Samples tested in accordance with Section 19 (b) which represent rejected forgings shall be preserved for two weeks from the date of test report. In case of dissatisfaction with results of tests, the manufacturer may make claim for a rehearing within that time.

22. **FREIGHT CHARGES.**—All rejected forgings will be returned to the manufacturer, who shall pay freight charge both ways.

SPECIFICATIONS FOR QUENCHED AND TEMPERED CARBON-STEEL AXLES, SHAFTS AND OTHER FORGINGS FOR LOCOMOTIVES. RECOMMENDED PRACTICE.

In 1914 the following specifications for quenched and tempered carbon-steel axles, shafts and other forgings for locomotives were adopted as Recommended Practice. Revised in 1915:

SPECIFICATIONS FOR QUENCHED AND TEMPERED CARBON-STEEL AXLES, SHAFTS AND OTHER FORGINGS FOR LOCOMOTIVES AND CARS.

Specifications for Quenched and Tempered Carbon Steel Forgings.

1. **BASIS OF PURCHASE.**— These specifications are to cover the various classes of carbon steel forgings now commonly used in locomotive construction.

I. Manufacture.

2. **PROCESS.**— The steel may be made by the open-hearth or other process approved by the purchaser.

3. **DISCARD.**—A sufficient discard shall be made from each ingot to secure freedom from injurious piping and undue segregation.

4. **PROLONGATION FOR TEST.**— For test purposes a prolongation shall be left on each forging, unless otherwise specified by the purchaser.

5. **BORING.**—(a) All forgings over seven inches in diameter shall be bored, unless otherwise specified by the purchaser. The boring shall be done before quenching.

(b) If boring is specified, the diameter of the hole shall be at least 20 per cent of the maximum outside diameter or thickness of the forging, exclusive of collars and flanges.

6. **HEAT TREATMENT.**— For quenching and tempering, the forgings shall be allowed to become cold after forging. They shall then be uniformly reheated to the proper temperature to refine the grain (a group thus reheated being known as a quenching charge) and quenched in some medium under substantially uniform conditions for each quenching charge. Finally they shall be uniformly reheated to the proper temperature for tempering or "drawing back" (a group thus reheated being known as a tempering charge) and allowed to cool uniformly.

II. Chemical Properties and Tests.

7. **CHEMICAL COMPOSITION.**— The steel shall conform to the following requirements as to chemical composition.

Carbon	First class	0.38 —0.52	per cent.
	Second class	0.45 —0.60	per cent.
Manganese		0.40 —0.70	per cent.
Phosphorus	not over	0.05	per cent.
Sulphur	not over	0.05	per cent.

8. **LADLE ANALYSIS.**—An analysis shall be made by the manufacturer from a test ingot taken during the pouring of each melt, a copy of which shall be given the purchaser or his representative. This analysis shall conform to the requirements specified in Section 7.

9. **CHECK ANALYSIS.**—(a) An analysis may be made by the purchaser from a forging representing each melt, which shall conform to the requirements specified in Section 7. Drillings for analysis may be taken from a forging, or from a full-sized prolongation of the same, at any point midway between the center and surface of solid forgings, and at any point midway between the inner and outer surfaces of the wall of the bored forgings, or turnings may be taken from a test specimen.

(b) In addition to the complete analysis a phosphorus determination may be made by the purchaser from each broken tension test specimen, and this determination shall conform to the requirements for phosphorus specified in Section 7.

III. Physical Properties and Tests.

10. **TENSION TESTS.**—(a) The forgings shall conform to the requirements as to tensile properties specified in Table 1.

Table No. 1.

For forgings whose diameter or thickness is not over ten inches when solid.

Size.	Tens. str. lb. per sq. in.	Elastic limit lb. per sq. in.	Elongation in 2 in. per cent.		Reduction of Area per cent.	
			Inverse ratio.	Not under	Inverse ratio.	Not under
First Class. Up to 7 in. outside diameter or thickness when solid, or 3½-in. max. wall when bored.....	85 000	50 000	2 000 000 / Tens. str.	20.5	3 800 000 / Tens. str.	39
Second Class. Over 7 to 10 in., incl., outside diameter or thickness when solid, or 5-in. max. wall when bored....................	85 000	50 000	1 900 000 / Tens. str.	19 5	3 600 000 / Tens. str.	37

(b) The classification by size of the forgings shall be determined by the specified diameter or thickness which governs the size of the prolongation from which test specimen is taken.

(c) Elastic limit shall be determined by means of an extensometer of a type the equal of the "Berry" strain gage.

(d) Test of forgings shall be made only after final treatment.

(e) The speed of the test machine shall not exceed ⅛ in. per minute until the elastic limit has been reached.

11. **BEND TESTS.**— If specified by the purchaser, bend tests shall be made as follows:

(a) For the first class by size, the test specimen shall bend cold through 180 deg. around a 1-in. flat mandrel having a rounded edge of ½-in. radius without cracking on the outside of the bent portion.

(b) For the second class by size, the test specimen shall bend cold through 180 deg. around a 1½-in. flat mandrel having a rounded edge of ¾-in. radius, without cracking on the outside of the bent portion.

12. **PROOF TEST.**—(a) Unless otherwise specified by the purchaser, all forgings shall be subjected to an impact proof test. The details of this test shall be agreed upon by the manufacturer and the purchaser.

(b) A recommended test for axles, shafts and similar forgings is as follows: Place the forging upon supports 3 ft. apart mounted on an M. C. B. drop test machine. The forging should then be struck two blows by a tup weighing either 1640 or 2240 lb. falling from heights proportioned according to the following formula and tabulation. Between the first and second blows the forging shall be turned 90 deg.

Height of drop in feet $= .01D^3$ for 1640-lb. tup.
Height of drop in feet $= .0073D^3$ for 2240-lb. tup.

NOTE.— D = Diameter of shaft or thickness of forging at center in inches.

TABLE No. 2.

Diameter of Shaft at center, inches.	Height of drop in feet.	
	1 640-lb. tup.	2 240-lb. tup.
5	1 ft. 3 in	0 ft. 11 in.
5½	1 ft. 8 in	1 ft. 3 in.
6	2 ft. 2 in	1 ft. 7 in.
6½	2 ft. 9 in	2 ft. 0 in.
7	3 ft. 5 in	2 ft. 6 in.
7½	4 ft. 3 in	3 ft. 1 in.
8	5 ft. 1 in	3 ft. 9 in.
8½	6 ft. 2 in	4 ft. 6 in.
9	7 ft. 3 in	5 ft. 4 in.
9½	8 ft. 7 in	6 ft. 3 in.
10	10 ft. 0 in	7 ft. 4 in.
10½	11 ft. 7 in	8 ft. 5 in.
11	13 ft. 4 in	9 ft. 9 in.
11½	15 ft. 3 in	11 ft. 3 in.
12	17 ft. 3 in	12 ft. 7 in.
12½	19 ft. 5 in	14 ft. 3 in.
13	22 ft. 0 in	16 ft. 0 in.
13½	24 ft. 7 in	18 ft. 0 in.
14	27 ft. 5 in	20 ft. 0 in.
14½	30 ft. 6 in	22 ft. 3 in.
15	33 ft. 9 in	24 ft. 8 in.

NOTE.— The above heights are to the nearest inch.

13. **TEST SPECIMEN.**—(a) Tension and bend test specimens shall be taken from a full size prolongation of any forging. For forgings with large ends or collars, the prolongation may be of the same cross section as that of the forging back of the large end or collar. Specimens may be taken from the forging itself with a hollow drill, if approved by the purchaser.

(b) The axis of the specimen shall be located at any point midway between the center and surface of solid forgings, and at any point midway between the inner and outer surfaces of the wall of the bored forgings, and shall be parallel to the axis of the forging in the direction in which the metal is most drawn out.

(c) Tension test specimens shall be of the form and dimensions shown in Fig. 1.

(d) Bend test specimens shall be ½ in. square in section with corners rounded to a radius not over $\frac{1}{16}$ in. and need not exceed 6 in. in length.

FIG. 1.

14. **NUMBER OF TESTS.**—(a) One tension, and if specified by the purchaser, one bend test shall be made from each tempering charge. If more than one quenching charge is represented in a tempering charge, one tension and, if specified, one bend test shall be made from each quenching charge. If more than one melt is represented in a quenching charge, one tension and, if specified, one bend test shall be made from each melt.

(b) If more than one class of forgings by size is represented in any lot, one tension, and if specified, one bend test from a forging of each class by size shall be made as specified in Sections 10, 11 and 13.

(c) If any test specimen shows defective machining or develops flaws, it may be discarded and another specimen substituted.

(d) If the percentage of elongation of any test specimen is less than that specified in Section 10 (a) and any part of the fracture is more than ¾ in. from the center of the gage length, as indicated by the scribe scratches marked on the specimen before testing, a retest shall be allowed.

15. **RETESTS.**—(a) If the fracture of any tension test specimen shows over 15 per cent crystalline, a second test shall be made. If the fracture of the second specimen shows over 15 per cent crystalline, the forgings represented by such specimen shall be retempered or requenched and retempered.

(b) If the results of the physical tests of any test lot do not conform to the requirements specified, the manufacturer may retemper or requench and retemper such lot, but not more than three additional times, unless authorized by the purchaser, and retests shall be made as specified in Section 14.

IV. WORKMANSHIP AND FINISH.

16. **WORKMANSHIP.**— The forgings shall conform to the sizes and shapes specified by the purchaser. Axles, shafts and similar forgings, unless otherwise specified, shall be rough turned with an allowance of ⅛ in. on the surface for finishing, except on the collars of axles or other forgings, which shall be left rough forged. In centering 60 deg. centers with clearance drilled for points shall be used.

17. **FINISH.**— The forgings shall be free from injurious defects and shall have a workmanlike finish.

V. Marking.

18. **MARKING.**— Identification marks shall be legibly stamped on each forging and on each test specimen. The purchaser shall indicate the location of such identification marks.

VI. Inspection and Rejection.

19. **INSPECTION.**—(a) The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the forgings ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the forgings are being furnished in accordance with these specifications. Tests and inspection at the place of manufacture shall be made prior to shipment.

(b) The purchaser may make the tests to govern the acceptance or rejection of the forgings in his own laboratory or elsewhere. Such tests, however, shall be made at the expense of the purchaser.

(c) Tests and inspection shall be so conducted as not to interfere with the operation of the works.

20. **REJECTION.**—(a) Unless otherwise specified, any rejection based on tests made in accordance with Section 19 (b) shall be reported within five working days from the receipt of the samples.

(b) Forgings which show injurious defects while being finished by the purchaser will be rejected, and the manufacturer shall be notified.

21. **REHEARING.**— Samples tested in accordance with Section 19 (b) which represent rejected forgings shall be preserved for two weeks from the date of test report. In case of dissatisfaction with results of tests, the manufacturer may make claim for a rehearing within that time.

22. **FREIGHT CHARGES.**—All rejected forgings will be returned to the manufacturer, who shall pay freight charges both ways.

CHECKING FORMULÆ FOR MAIN AND SIDE RODS.

STANDARD.

In 1913 the following formulæ for calculating stresses in main and side rods were adopted as Recommended Practice; in 1914 advanced to standard:

CHECKING FORMULAE.

All Measurements Are Given in Inches and Pounds.

A = area of section considered.

a = width of section considered.

b = depth of section considered.

C_1 = max. compression unit stress for transverse bending.

C_2 = max. compression unit stress for vertical bending.

$c - c_1 - c_2$ = coefficients.

d = cylinder diameter.

L = length of rod from center to center of pins.

M = bending moment.

P = max. compression strain acting at end of rod.

p = max. boiler pressure.

Q = cylinder pressure = $0.7854\ d^2\ p$.

R = radius of driving wheels.

r = radius of crank.

$\overline{RG}$ = radius of gyration of section — axis horizontal

$\overline{rg}$ = radius of gyration of section — axis vertical.

S = stress, and where used in formulæ must not exceed one-sixth of ultimate strength of the steel.

s = amount of horizontal offset in rod.

$\overline{SM}$ = section modulus of section considered — axis horizontal.

$\overline{sm}$ = section modulus of section considered — axis vertical.

W = weight on pairs of drivers actuated through rod considered.

Main rod area must not be less than $P \div 10{,}000$ pounds.

For main rods, $P = Q$.

For side rods, $P = \dfrac{0.3\ WR}{r}$

To determine C_1 and C_2, calculations should be based on a section half way between rod pins.

For transverse bending in rods having knuckle pins flexible transversely:

$$C_1 = \frac{\dfrac{P}{A}}{1 - \dfrac{PL^2}{575{,}000{,}000\ A\ rg^2}}$$

For all other rods:

$$C_1 = \frac{\dfrac{P}{A}}{1 - \dfrac{PL^2}{1{,}200{,}000{,}000\ A\ rg^2}}$$

For vertical bending in all rods:

$$C_2 = \frac{\dfrac{P}{A}}{1 - \dfrac{PL^2}{300{,}000{,}000\ A\ RG^2}}$$

Values for C_1 and C_2 can also be taken from tables in "Kent's Pocket Book," under heading, "Merriman's Rational Formula for Columns."

First:

For rods without offset the larger value of C_1 and C_2 should be taken equal to S.

For rods with offset the larger value of $C_1 + \dfrac{Ps}{sm}$ and C_2 should be taken equal to S.

Second:

$$S = c \frac{AL^2r}{\underline{SM}} + c_1 P \left(\frac{1}{A} + \frac{s}{\underline{sm}} \right)$$

The calculations should be based on a section located at a distance 0.6 L from crosshead pin for main rods, and half way between pins for side rods.

VALUES OF C AND C_1

REV. PER MIN.		265	325	375	420
Main Rod.....	C =	0.036	0.055	0.073	0.091
	C_1 =	0.500	0.500	0.400	0.300
Side Rod......	C =	0.071	0.106	0.142	0.177
	C_1 =	0.500	0.500	0.500	0.500

The coefficients selected should correspond with the highest number of revolutions per minute which the locomotive can make.

If this can not be determined, use:

420 r. p. m. for high-speed locomotives.

375 r. p. m. for passenger and high-speed freight locomotives.

325 r. p. m. for all other locomotives.

Very simple rules for rods, without offset, and having bodies with rectangular section, based on the above theory, follow.

First:

Stress is less than one-sixth of ultimate strength of the steel if "L" is less than 46 "a" or 23 "b," and if "A" is more than "P" divided by one-eighth of ultimate strength of the steel.

Second:

$$S = c_2 \frac{L^2r}{b} + c_1 \frac{P}{A}$$

VALUES OF C_2 and C_1

REV. PER MIN.		265	325	375	420
Main Rod.....	C_2 —	0.22	0.33	0.44	0.55
	C_1 —	0.50	0.50	0.40	0.30
Side Rod......	C_2 —	0.43	0.64	0.85	1.06
	C_1 —	0.50	0.50	0.50	0.50

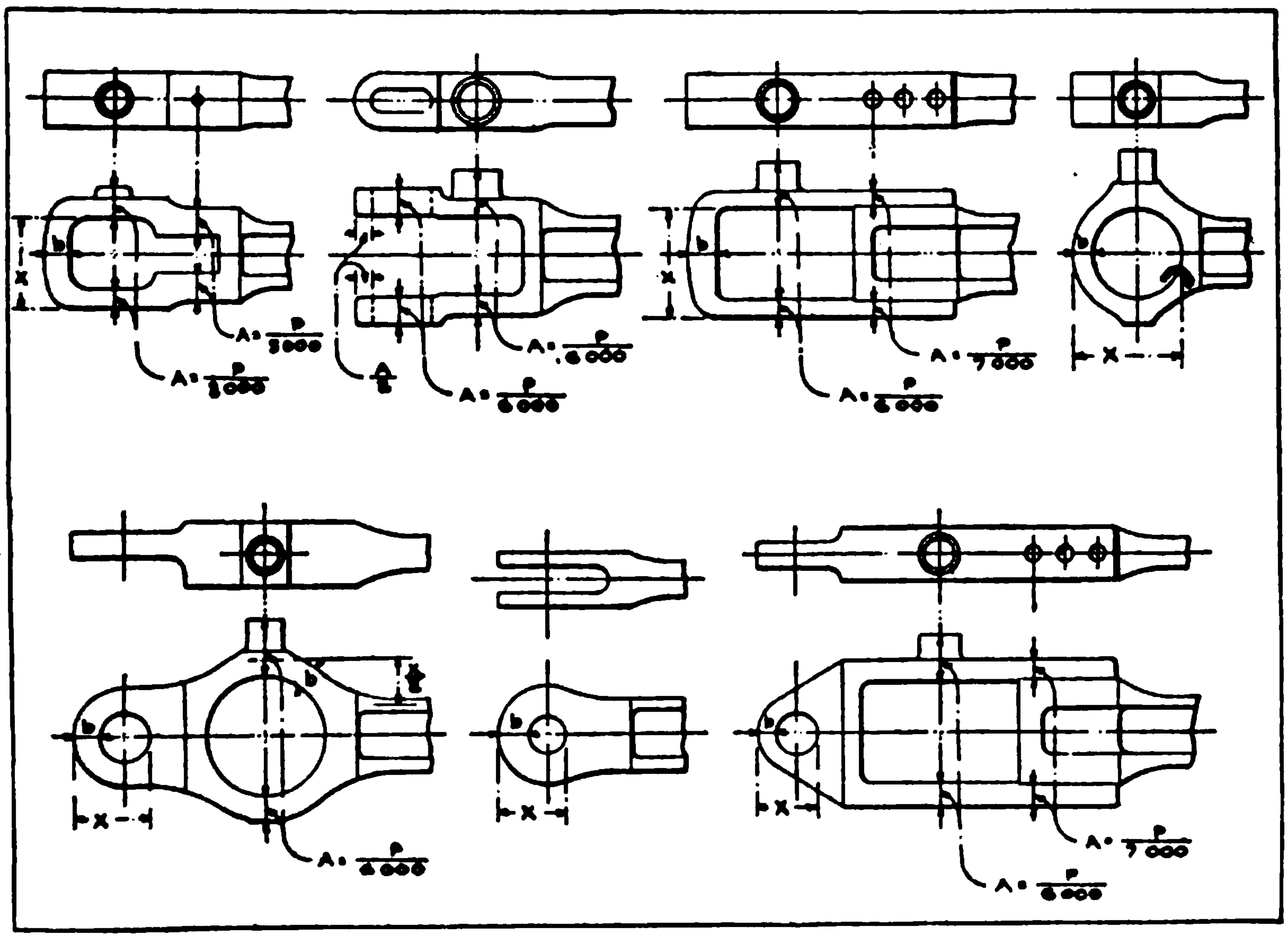
The allowable stresses for the various sections of rod ends are given in connection with the diagrams following, except where thickness of section is indicated by the letter "b." The figures denote maximum stress allowed under end load "P." If the minimum areas of the two members differ, take double the lesser area for "A."

The minimum area at points indicated by letter "b":

For main rods and main pin bearing of side rod, $A = \dfrac{PX}{30{,}000\ b}$

For side rods, except main pin bearing, $A = \dfrac{PX}{60{,}000\ b}$

In which "X" is the average diameter of eye or average spread of jaw members.



SPECIFICATIONS FOR DETERMINING THE SIZE OF SAFETY VALVES, THEIR APPLICATION TO LOCOMOTIVES AND THEIR REPAIRS.

STANDARD.

Adopted as standard in 1912.

1. FORMULA FOR DETERMINING THE SIZE OF VALUE REQUIRED, ASSUMING VALVES HAVE 45-DEGREE SEAT.

D — The total of the actual diameters of the inner edge of the seats of valves required.

H — Total heating surface of boiler in square feet. (Superheating surface not to be included.)

L — Vertical lift of valve in inches.

P — Absolute boiler pressure in lbs. per square inch.

$$D = .036 \times \frac{H}{L \times P}$$

EXAMPLE.

$$\frac{.036 \times 2878}{.1 \times 200} = 5.2'' \text{ Diameter}$$

which would require two 3-inch valves.

METHOD OF DETERMINING MAXIMUM CAPACITY OF SAFETY VALVES.

2. The only accurate method of determining the capacity of safety valves is by actual test in a testing plant, with safety valves fully equipped with springs, as in actual road service. In order that it should be positively known that safety valves will prevent undue rise in pressure under extreme conditions, they should be subjected to a road test.

NUMBER AND SIZE TO BE APPLIED.

3. Every locomotive should be equipped with not less than two, and not more than three safety valves, the size to be determined as per formula in paragraph 1. Safety valves to be set as follows:

First — Boiler pressure.

Second — Two pounds in excess.

Third — Three pounds above second, or five pounds in excess of first.

METAL RECOMMENDED FOR VALVES AND VALVE SEATS.

4. Bronze alloys should be used in the manufacture of valves and valve seats.

STAMPING LIFT ON VALVES.

5. Manufacturers should be required to stamp on the valve the lift in inches and the discharge capacity in pounds per minute, as determined by

actual test, with valve in working condition, and set for a blow-back of not to exceed 3 pounds.

ESTIMATING STEAM DISCHARGE.

6. Steam discharge from safety valves of given size can be estimated closely by the use of Napier's rule for flow of steam, as follows:

Flow of steam per second:

Absolute pressure in pounds per square inch, multiplied by area in square inches of discharge opening, divided by 70.

Multiplied by 3,600 gives flow in pounds per hour.

LOCATION OF VALVES ON BOILER.

7. Safety valves should be located at the highest point on the boiler, where clearance limits will permit, in vertical position, avoiding the use of piping, long nipples and ells between safety valves and boiler.

SPACING IN DOME.

8. Where safety valves are located on an independent dome, they should be spaced as per Plate No. 1. The opening from boiler into dome and the area between supporting ribs in dome should not be less than inlet area of valves.

HYDROSTATIC AND OTHER TESTS.

9. The screwing down of the safety valve spring during a hydrostatic test of boiler should not be practiced. Valves with springs designed for certain pressures should not be subjected to extreme pressures. One safety valve should be removed and replaced with a special high-pressure valve, and the other valves should be removed and replaced with caps or plugs during test.

STANDARD CONNECTIONS.

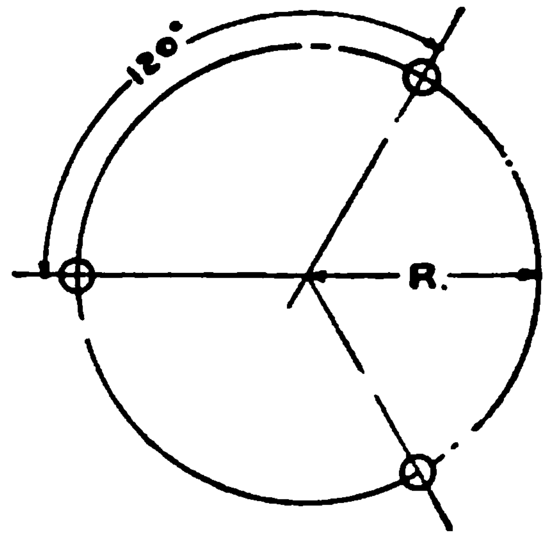
10. In order to make valves of different manufacture interchangeable, standard thread and diameter of valves at connection should be used, as follows:

2½-in. safety valve	2½-in. U. S. S. pipe thread	8 threads to in.
3 -in. safety valve	3 -in. U. S. S. pipe thread	8 threads to in.
3½-in. safety valve	3½-in. U. S. S. pipe thread	8 threads to in.
4 -in. safety valve	4 -in. U. S. S. pipe thread	8 threads to in.
4½-in. safety valve	4½-in. U. S. S. pipe thread	8 threads to in.

Valves of above sizes to be made for U. S. S. wrench fit.

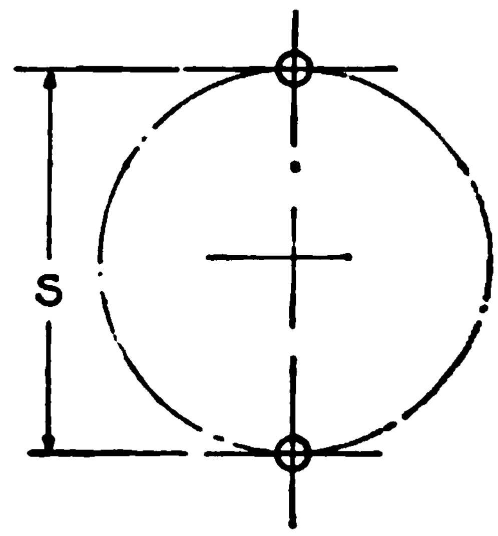
PLATE—I.

VALVE SIZE	SPACING S	RADIUS R
$4\frac{1}{2}$"	9"	$5\frac{3}{16}$"
4"	$8\frac{1}{2}$"	$4\frac{7}{8}$"
$3\frac{1}{2}$"	8"	$4\frac{5}{8}$
3"	$7\frac{1}{4}$	$4\frac{3}{16}$
$2\frac{1}{2}$"	$6\frac{1}{2}$"	$3\frac{3}{4}$"



THREE VALVES

APPLICATIONS MADE AS DESCRIBED PERMIT USE OF WRENCH FITS RECOMENDED & MOVEMENT OF STANDARD WRENCH ONE SIXTH OF A TURN WITH A REASONABLE MARGIN



TWO VALVES.

Inspection of Old Springs.

11. Old springs should be tested as to their deflection under load before being used in repaired valves.

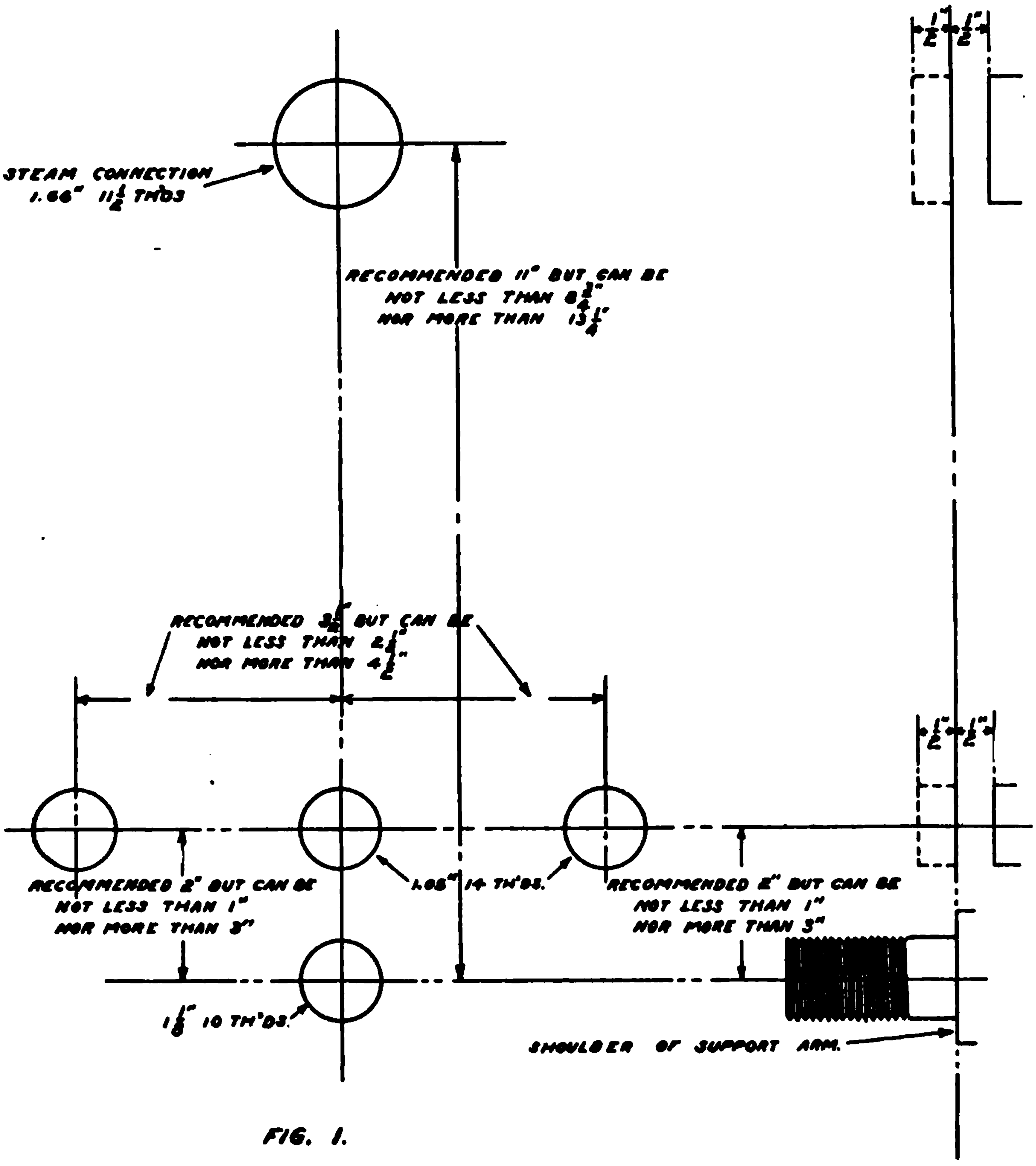
Repairs to Safety Valves.

12. Safety valves should be thoroughly overhauled and put in good condition whenever the locomotive is in shop for general repairs. Standard gauges should be used in order that important dimensions may be maintained as originally designed.

FITTINGS FOR LUBRICATORS. STANDARD.

At the convention of 1906 the Committee on Locomotive Lubrication proposed a standard location of holding arm shoulder and oil and steam connection joint faces; also a system of fittings and joints for all connections. Fig. 1 shows the location for connection of joints and holding arm. Figs. 2, 3, 4 and 5 show pipe joints and fittings, and Fig. 6 illustrates the holding arm proposed.

On reference to letter ballot they were adopted as standard. They are as shown herewith.



STEAM CONNECTION
1.66" 11½ TH'DS
RECOMMENDED 11" BUT CAN BE
NOT LESS THAN 6¾"
NOR MORE THAN 13¼"
RECOMMENDED 3½" BUT CAN BE
NOT LESS THAN 2½"
NOR MORE THAN 4½"
½"
½"
RECOMMENDED 2" BUT CAN BE
NOT LESS THAN 1"
NOR MORE THAN 3"
1.05" 14 TH'DS.
RECOMMENDED 2" BUT CAN BE
NOT LESS THAN 1"
NOR MORE THAN 3"
1⅛" 10 TH'DS.
SHOULDER OF SUPPORT ARM.

FIG. 1.

FIG. 2.

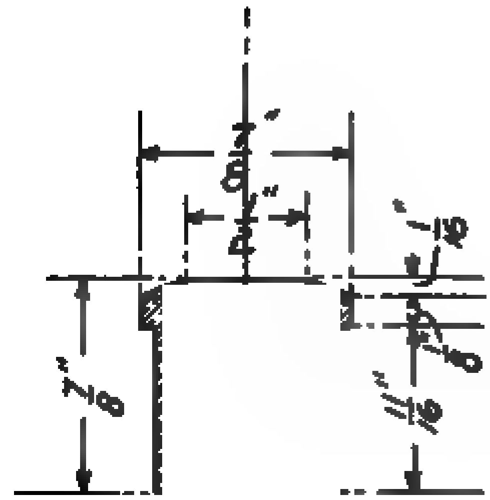


FIG. 3.

FIG. 4

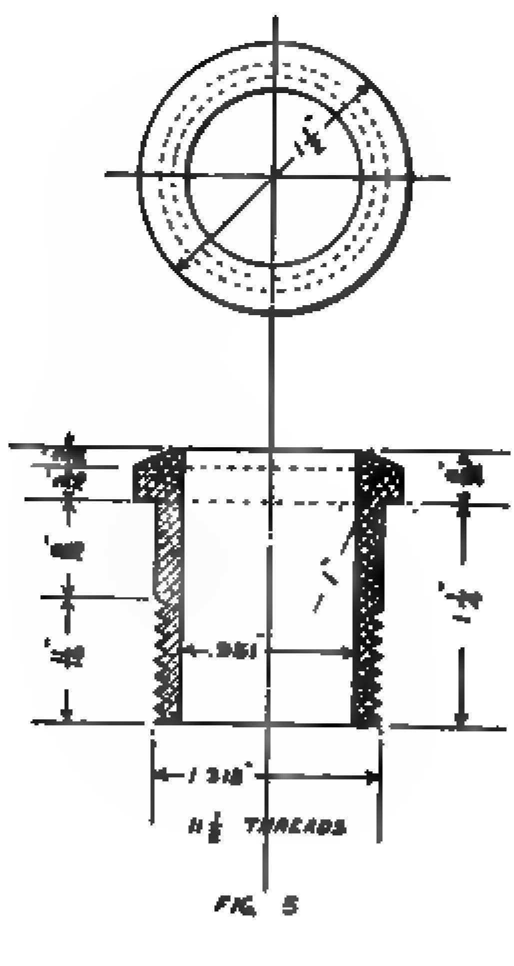
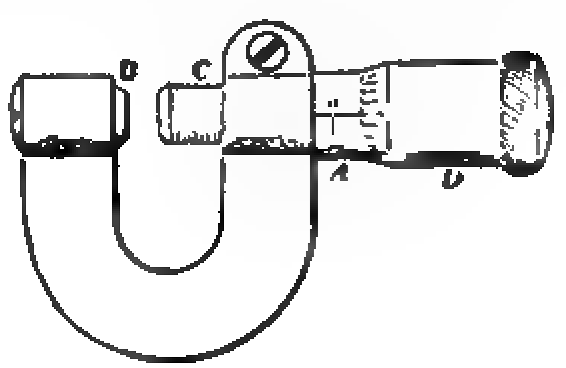


FIG. 5

At the convention of 1882 the Brown & Sharpe micrometer gauge shown below was adopted as standard for the measurement of sheet metal (see page 132, report 1882). Reaffirmed 1891 (see pages 160, 161, report 1891).

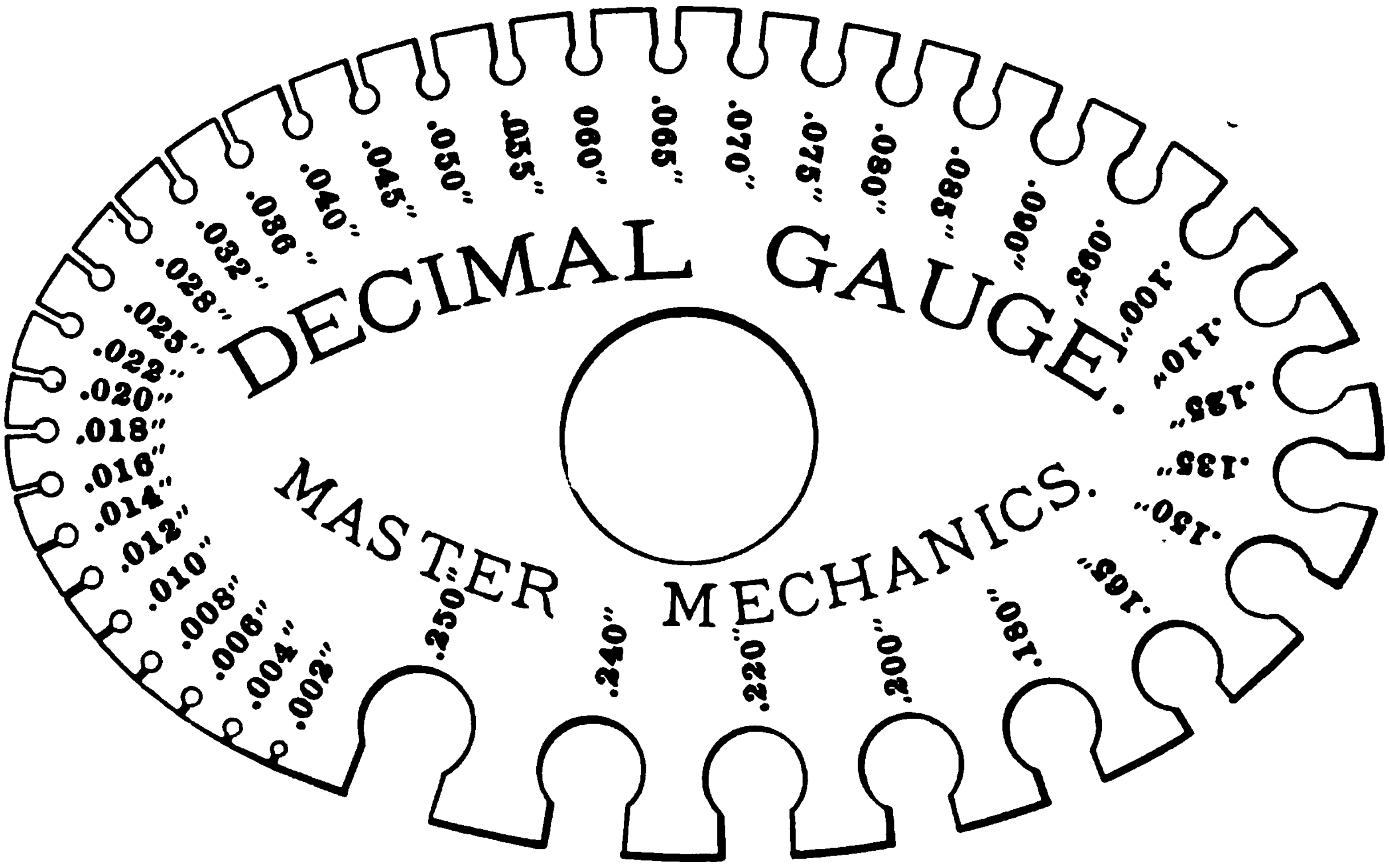


At the convention of 1895 the following was adopted as a standard Decimal Gauge:

1st. The micrometer caliper should be used for laboratory and tool-room work, and in the shop when specially desired.

2d. The solid notch gauge should be used for general shop purposes.

3d. The form of this gauge shall be an ellipse whose major axis is 4 inches, the minor axis 2.5 inches, and the thickness .1 inch, with a central hole .75 inch in diameter.



4th. The notches in this gauge shall be as follows:

.002″	.022″	.060″	.110″
.004″	.025″	.065″	.125″
.006″	.028″	.070″	.135″
.008″	.032″	.075″	.150″
.010″	.036″	.080″	.165″
.012″	.040″	.085″	.180″
.014″	.045″	.090″	.200″
.016″	.050″	.095″	.220″
.018″	.055″	.100″	.240″
.020″	.....	.....	.250″

5th. All notches to be marked as in the above list.

6th. The gauge must be plainly stamped with the words "Decimal Gauge" in capital letters .2 inch high, and below this the words "Master Mechanics."

7th. In ordering material, the term gauge shall *not* be used, but the thickness ordered by writing the decimal as in above list. For sizes over ¼ inch, the ordinary common fractions may be used.

DIMENSIONS AND THREADS OF WROUGHT PIPE. STANDARD.

At the convention of 1899, what is known as the Briggs Standard, as determined by the Pratt & Whitney gauges, of threads for wrought-iron pipe and couplings, was adopted as a standard of the Association.

The gauges used by the Pratt & Whitney Company were made by them from an autograph copy of a table made by Mr. Robert Briggs personally, who originally established and published these standard threads.

In 1908 these dimensions were revised and 11-inch and 12-inch pipe included. The words "wrought pipe" in the above heading include wrought iron and steel pipe.

Diameter of Tube.			Thickness of metal.	Screwed Ends.	
Nominal inside.	Actual inside.	Actual outside.		Number of threads per inch.	Length of perfect screw.
Inches.	Inches.	Inches.	Inch.	No.	Inch.
⅛	.269	0.405	0.068	27	0.19
¼	.364	0.540	0.088	18	0.29
⅜	.493	0.675	0.091	18	0.30
½	.622	0.840	0.109	14	0.39
¾	.824	1.050	0.113	14	0.40
1	1.047	1.315	0.134	11½	0.51
1¼	1.380	1.660	0.140	11½	0.54
1½	1.610	1.900	0.145	11½	0.55
2	2.067	2.375	0.154	11½	0.58
2½	2.467	2.875	0.204	8	0.89
3	3.066	3.500	0.217	8	0.95
3½	3.548	4.000	0.226	8	1.00
4	4.026	4.500	0.237	8	1.05
4½	4.508	5.000	0.246	8	1.10
5	5.045	5.563	0.259	8	1.16
6	6.065	6.625	0.280	8	1.26
7	7.023	7.625	0.301	8	1.36
8	7.981	8.625	0.322	8	1.46
9	8.937	9.625	0.344	8	1.57
10	10.018	10.750	0.366	8	1.68
11	11.000	11.750	0.375	8	1.79
12	12.000	12.750	0.375	8	1.90

Tapers of conical tube ends, 1 in 32 to axis of tube. (¾-inch per foot.)

By the late action of the Manufacturers of Wrought-Iron Pipe, 9-inch outside diameter has been excepted from the original list, as above noted, the diameter now adopted being 9.625 instead of 9.688 inches given in the Briggs table.

PIPE UNIONS. STANDARD.

Sheet M. M. 19.

At the convention of 1902 standard dimensions for pipe unions ⅛ to 4 inches, inclusive, were proposed for adoption, and, at the convention of 1903, the same were adopted as standard. These dimensions are shown on Sheet M. M. 19.

SAFETY APPLIANCES.

SAFETY APPLIANCES. STANDARD.

In 1913 the United States Safety Appliances, as contained in the order of the Interstate Commerce Commission, dated March 13, 1911, were adopted as Standard. Revised 1915.

STEAM LOCOMOTIVES USED IN ROAD SERVICE.

TENDER SILL-STEPS.

Number. Four (4) on tender.

Dimensions. Bottom tread not less than eight (8) by twelve (12) inches, metal. [*May have wooden treads.*]

If stirrup-steps are used, clear length of tread shall be not less than ten (10), preferably twelve (12), inches.

Location. One (1) near each corner of tender on sides.

Manner of Application. Tender sill-steps shall be securely fastened with bolts or rivets.

PILOT SILL-STEPS.

Number. Two (2).

Dimensions. Tread not less than eight (8) inches in width by ten (10) inches in length, metal. [*May have wooden treads.*]

Location. One (1) on or near each end of buffer-beam outside of rail and not more than sixteen (16) inches above rail.

Manner of Application. Pilot sill-steps shall be securely fastened with bolts or rivets.

PILOT-BEAM HANDHOLDS.

Number. Two (2).

Dimensions. Minimum diameter, five-eighths (5/8) of an inch, wrought iron or steel. Minimum clear length, fourteen (14), preferably sixteen (16), inches. Minimum clearance, two and one-half (2½) inches.

Location. One (1) on each end of buffer-beam. [*If uncoupling-lever extends across front end of locomotive to within eight* (8) *inches of end of buffer-beam, and is seven-eighths* (7/8) *of an inch or more in diameter, securely fastened, with a clearance of two and one-half* (2½) *inches, it is a handhold.*]

Manner of Application. Pilot-beam handholds shall be securely fastened with bolts or rivets.

SIDE HANDHOLDS.

Number. Six (6).

Dimensions. Minimum diameter, if horizontal, five-eighths (5/8) of an inch; if vertical, seven-eighths (7/8) of an inch, wrought iron or steel.

Horizontal, minimum clear length, sixteen (16) inches.

Vertical, clear length equal to approximate height of tank.

Minimum clearance two (2), preferably two and one-half (2½), inches..

Horizontal or vertical: If vertical, one (1) on each side of tender within six (6) inches of rear or on corner, if horizontal, same as specified for "Box and other house cars." **Location.**

One (1) on each side of tender near gangway; one (1) on each side of locomotive at gangway; applied vertically.

Side handholds shall be securely fastened with not less than one-half (½) inch bolts or rivets. **Manner of Application.**

REAR-END HANDHOLDS.

Two (2). **Number.**

Minimum diameter, five-eighths (⅝) of an inch, wrought iron or steel. **Dimensions.**

Minimum clear length, fourteen (14) inches.

Minimum clearance two (2), preferably two and one-half (2½), inches.

Horizontal: One (1) near each side of rear end of tender on face of end-sill. Clearance of outer end of handhold shall be not more than sixteen (16) inches from side of tender. **Location.**

Rear-end handholds shall be securely fastened with not less than one-half (½) inch bolts or rivets. **Manner of Application.**

UNCOUPLING-LEVERS.

Two (2) double levers, operative from either side. **Number.**

Rear-end levers shall extend across end of tender with handles not more than twelve (12), preferably nine (9), inches from side of tender with a guard bent on handle to give not less than two (2) inches clearance around handle. **Dimensions.**

One (1) on rear end of tender and one (1) on front end of locomotive. Handles of front-end levers shall be not more than twelve (12), preferably nine (9), inches from ends of buffer-beam, and shall be so constructed as to give a minimum clearance of two (2) inches around handle. **Location.**

Uncoupling-levers shall be securely fastened with bolts or rivets. **Manner of Application.**

COUPLERS.

Locomotives shall be equipped with automatic couplers at rear of tender and front of locomotive.

STEAM LOCOMOTIVES USED IN SWITCHING SERVICE.

FOOTBOARDS.

Number. Two (2) or more.

Dimensions. Minimum width of tread, ten (10) inches, wood.

Minimum thickness of tread, one and one-half (1½), preferably two (2) inches.

Minimum height of back-stop, four (4) inches above tread.

Height from top of rail to top of tread, not more than twelve (12) nor less than nine (9) inches.

Location. Ends or sides.

If on ends, they shall extend not less than eighteen (18) inches outside of gauge of straight track, and shall be not more than twelve (12) inches shorter than buffer-beam at each end.

Manner of Application. End footboards may be constructed in two (2) sections, *provided* that practically all space on each side of coupler is filled; each section shall be not less than three (3) feet in length.

Footboards shall be securely bolted to two (2) one (1) by four (4) inches metal brackets, *provided* footboard is not cut or notched at any point.

If footboard is cut or notched or in two (2) sections, not less than four (4) one (1) by three (3) inches metal brackets shall be used, two (2) located on each side of coupler. Each bracket shall be securely bolted to buffer-beam, end-sill or tank-frame by not less than two (2) seven-eighths (⅞) inch bolts.

If side footboards are used, a substantial handhold or rail shall be applied not less than thirty (30) inches nor more than sixty (60) inches above tread of footboard.

SILL-STEPS.

Number. Two (2) or more.

Dimensions. Lower tread of step shall be not less than eight (8) by twelve (12) inches, metal. [*May have wooden treads.*]

If stirrup-steps are used, clear length of tread shall be not less than ten (10), preferably twelve (12), inches.

Location. One (1) or more on each side at gangway secured to locomotive or tender.

Manner of Application. Sill-steps shall be securely fastened with bolts or rivets.

END HANDHOLDS.

Number. Two (2).

Dimensions. Minimum diameter, one (1) inch, wrought iron or steel.

Minimum clearance, four (4) inches, *except* at coupler casting or braces, when minimum clearance shall be two (2) inches.

One (1) on pilot buffer-beam; one on rear end of tender, extending across front end of locomotive and rear end of tender. Ends of handholds shall be not more than six (6) inches from ends of buffer-beam or end-sill, securely fastened at ends. **Location.**

End handholds shall be securely fastened with bolts or rivets. **Manner of Application.**

SIDE-HANDHOLDS.

Four (4). **Number.**

Minimum diameter, seven-eighths (7/8) of an inch, wrought iron or steel. **Dimensions.**

Clear length equal to approximate height of tank.

Minimum clearance, two (2), preferably two and one-half (2½), inches.

Vertical. One (1) on each side of tender near front corner; one (1) on each side of locomotive gangway. **Location.**

Side handholds shall be securely fastened with bolts or rivets. **Manner of Application.**

UNCOUPLING-LEVERS.

Two (2) double levers, operative from either side. **Number.**

Handles of front-end levers shall be not more than twelve (12), preferably nine (9), inches from ends of buffer-beam, and shall be so constructed as to give a minimum clearance of two (2) inches around handle. **Dimensions.**

Rear-end levers shall extend across end of tender with handles not more than twelve (12), preferably nine (9), inches from side of tender, with a guard bent on handle to give not less than two (2) inches clearance around handle.

One (1) on rear end of tender and one (1) on front end of locomotive. **Location.**

HANDRAILS AND STEPS FOR HEADLIGHTS.

Switching-locomotives with sloping tenders with manhole or headlight located on sloping portion of tender shall be equipped with secure steps and handrail or with platform and handrail leading to such manhole or headlight.

END-LADDER CLEARANCE.

No part of locomotive or tender *except* draft-rigging, coupler and attachments, safety-chains, buffer-block, foot-board, brake-pipe, signal-pipe, steam-heat pipe or arms of uncoupling-lever shall extend to within fourteen (14) inches of a vertical plane passing through the inside face of knuckles when closed with horn of coupler against buffer-block or end-sill.

COUPLERS.

Locomotives shall be equipped with automatic couplers at rear of tender and front of locomotive.

SPECIFICATIONS COMMON TO ALL STEAM LOCOMOTIVES.

HAND-BRAKES.

Hand-brakes will not be required on locomotives nor on tenders when attached to locomotives.

If tenders are detached from locomotives and used in special service, they shall be equipped with efficient hand-brakes.

RUNNING-BOARDS.

Number. Two (2).

Dimensions. Not less than ten (10) inches wide. If of wood, not less than one and one-half ($1\frac{1}{2}$) inches in thickness; if of metal, not less than three-sixteenths ($\frac{3}{16}$) of an inch, properly supported.

Location. One (1) on each side of boiler extending from cab to front end near pilot-beam. [*Running-boards may be in sections. Flat-top steam-chests may form section of running-board.*]

Manner of Application. Running-boards shall be securely fastened with bolts, rivets or studs. Locomotives having Wootten type boilers with cab located on top of boiler more than twelve (12) inches forward from boiler-head shall have suitable running-boards running from cab to rear of locomotive, with handrailings not less than twenty (20) nor more than forty-eight (48) inches above outside edge of running-boards, securely fastened with bolts, rivets or studs.

HANDRAILS.

Number. Two (2) or more.

Dimensions. Not less than one (1) inch in diameter, wrought iron or steel.

Location. One on each side of boiler extending from near cab to near front end of boiler, and extending across front end of boiler, not less than twenty-four (24) nor more than sixty-six (66) inches above running-board.

Manner of Application. Handrails shall be securely fastened to boiler.

TENDERS OF VANDERBILT TYPE.

Tenders known as the Vanderbilt type shall be equipped with running-boards; one (1) on each side of tender not less than ten (10) inches in width and one on top of tender not less than forty-eight (48) inches in width, extending from coal space to rear of tender.

There shall be a handrail on each side of top running-board, extending from coal space to rear of tank, not less than one (1) inch in diameter and not less than twenty (20) inches in height above running-board from coal space to manhole.

There shall be a handrail extending from coal space to within twelve (12) inches of rear of tank, attached to each side of tank above side

running-board, not less than thirty (30) nor more than sixty-six (66) inches above running-board.

There shall be one (1) vertical end handhold on each side of Vanderbilt type of tender, located within eight (8) inches of rear of tank extending from within eight (8) inches of top of end-sill to within eight (8) inches of side handrail. Post supporting rear end of side running-board, if not more than two (2) inches in diameter and properly located, may form section of handhold.

An additional horizontal end handhold shall be applied on rear end of all Vanderbilt type of tenders which are not equipped with vestibules. Handhold to be located not less than thirty (30) nor more than sixty-six (66) inches above top of end-sill. Clear length of handhold to be not less than forty-eight (48) inches.

Ladders shall be applied at forward ends of side running-boards.

HANDRAILS AND STEPS FOR HEADLIGHTS.

Locomotives having headlights which can not be safely and conveniently reached from pilot-beam or steam-chests shall be equipped with secure handrails and steps suitable for the use of men in getting to and from such headlights.

A suitable metal end or side ladder shall be applied to all tanks more than forty-eight (48) inches in height, measured from the top of end-sill, and securely fastened with bolts or rivets.

COUPLERS.

Locomotives shall be equipped with automatic couplers at rear of tender and front of locomotive.

INSPECTION AND TESTING OF LOCOMOTIVE BOILERS. STANDARD.

In 1913 the Federal Regulations for the inspection and testing of locomotive boilers and their appurtenances, as contained in the order of the Interstate Commerce Commission, dated June 2, 1911, were adopted as Standard. They are as follows:

RESPONSIBILITY FOR THE GENERAL CONSTRUCTION AND SAFE WORKING PRESSURE.

1. The railroad company will be held responsible for the general design and construction of the locomotive boilers under its control. The safe working pressure for each locomotive boiler shall be fixed by the chief mechanical officer of the company or by a competent mechanical engineer under his supervision, after full consideration has been given to the general design, workmanship, age and condition of the boiler, and shall be determined from the minimum thickness of the shell plates, the lowest tensile strength of the plates, the efficiency of the longitudinal joint, the inside diameter of the course, and the lowest factor of safety allowed.

FACTOR OF SAFETY.

2. The lowest factor of safety to be used for locomotive boilers constructed after January 1, 1912, shall be 4.

The lowest factor of safety to be used for locomotive boilers which were in service or under construction prior to January 1, 1912, shall be as follows:

Effective January 1, 1915, the lowest factor shall be 3, except that upon application, this period may be extended not to exceed one year, if an investigation shows that conditions warrant it.

Effective January 1, 1916, the lowest factor shall be 3.25.

Effective January 1, 1917, the lowest factor shall be 3.5.

Effective January 1, 1919, the lowest factor shall be 3.75.

Effective January 1, 1921, the lowest factor shall be 4.

3. MAXIMUM ALLOWABLE STRESS ON STAYS AND BRACES.— For locomotives constructed after January 1, 1915, the maximum allowable stress per sq. in. of net cross sectional area on fire box and combustion chamber stays shall be 7500 lb. The maximum allowable stress per sq. in. of net cross sectional area on round, rectangular or gusset braces shall be 9000 lb.

For locomotives constructed prior to January 1, 1915, the maximum allowable stress on stays and braces shall meet the requirements of Rule No. 2, except that when a new fire box and wrapper sheet are applied to such locomotives, they shall be made to meet the requirements of Rule No. 3.

TENSILE STRENGTH OF MATERIAL.

4. When the tensile strength of steel or wrought-iron shell plates is not known, it shall be taken at 50,000 pounds for steel and 45,000 pounds for wrought iron.

SHEARING STRENGTH OF RIVETS.

5. The maximum shearing strength of rivets per square inch of cross-sectional area shall be taken as follows:

	Pounds.
Iron rivets in single shear	38,000
Iron rivets in double shear	76,000
Steel rivets in single shear	44,000
Steel rivets in double shear	88,000

6. A higher shearing strength may be used for rivets when it can be shown by test that the rivet material used is of such quality as to justify a higher allowable shearing strength.

RULES FOR INSPECTION.

7. The mechanical officer in charge at each point where boiler work is done will be held responsible for the inspection and repair of all locomotive boilers and their appurtenances under his jurisdiction. He must

know that all defects disclosed by any inspection are properly repaired before the locomotive is returned to service.

8. The term inspector as used in these rules and instructions, unless otherwise specified, will be held to mean the railroad company's inspector.

INSPECTION OF INTERIOR OF BOILER.

9. TIME OF INSPECTION.— The interior of every boiler shall be thoroughly inspected before the boiler is put into service, and whenever a sufficient number of flues are removed to allow examination.

10. FLUES TO BE REMOVED.—All flues of boilers in service, except as otherwise provided, shall be removed at least once every three years, and a thorough examination shall be made of the entire interior of the boiler. After flues are taken out, the inside of the boiler must have the scale removed and be thoroughly cleaned. This period for the removal of flues may be extended upon application if an investigation shows that conditions warrant it.

11. METHOD OF INSPECTION.— The entire interior of the boiler must then be examined for cracks, pitting, grooving, or indications of overheating and for damage where mud has collected, or heavy scale formed. The edges of plates, all laps, seams and points where cracks and defects are likely to develop, or which an exterior examination may have indicated, must be given an especially minute examination. It must be seen that braces and stays are taut, that pins are properly secured in place, and that each is in condition to support its proportion of the load.

12. REPAIRS.—Any boiler developing cracks in the barrel shall be taken out of service at once, thoroughly repaired, and reported to be in satisfactory condition before it is returned to service.

13. LAP JOINT SEAMS.— Every boiler having lap joint longitudinal seams without reinforcing plates shall be examined with special care to detect grooving or cracks at the edges of the seams.

14. FUSIBLE PLUGS.— If boilers are equipped with fusible plugs they shall be removed and cleaned of scale at least once every month. Their removal must be noted on the report of inspection.

INSPECTION OF EXTERIOR OF BOILER.

15. TIME OF INSPECTION.— The exterior of every boiler shall be thoroughly inspected before the boiler is put into service and whenever the jacket and the lagging are removed.

16. LAGGING TO BE REMOVED.— The jacket and lagging shall be removed at least once every five years and a thorough inspection made of the entire exterior of the boiler. The jacket and lagging shall also be removed whenever, on account of indications of leaks, the United States inspector or the railroad company's inspector considers it desirable or necessary.

TESTING BOILERS.

17. TIME OF TESTING.— Every boiler, before being put into service, and at least once every 12 months thereafter, shall be subjected to hydrostatic pressure twenty-five per cent above the working steam pressure.

18. REMOVAL OF DOME CAP.— The dome cap and throttle standpipe must be removed at the time of making the hydrostatic test, and the interior surface and connections of the boiler examined as thoroughly as conditions will permit. In case the boiler can be entered and thoroughly inspected without removing the throttle standpipe, the inspector may make the inspection by removing the dome cap only, but the variation from the rule must be noted in the report of inspection.

19. WITNESS OF TEST.— When the test is being made by the railroad company's inspector, an authorized representative of the company, thoroughly familiar with boiler construction, must personally witness the test and thoroughly examine the boiler while under hydrostatic pressure.

20. REPAIRS AND STEAM TEST.— When all necessary repairs have been completed, the boiler shall be fired up and the steam pressure raised to not less than the allowed working pressure, and the boiler and appurtenances carefully examined. All cocks, valves, seams, bolts and rivets must be tight under this pressure, and all defects disclosed must be repaired.

STAY-BOLT TESTING.

21. TIME OF TESTING RIGID BOLTS.—All stay bolts shall be tested at least once each month. Stay bolts shall also be tested immediately after every hydrostatic test.

22. METHOD OF TESTING RIGID BOLTS.— The inspector must tap each bolt and determine the broken bolts from the sound or the vibration of the sheet. If stay-bolt tests are made when the boiler is filled with water, there must be not less than 50 pounds pressure on the boiler. Should the boiler not be under pressure, the test may be made after draining all water from the boiler in which case the vibration of the sheet will indicate any unsoundness. The latter test is preferable.

23. METHOD OF TESTING FLEXIBLE STAY BOLTS WITH CAPS.—All flexible stay bolts having caps over the outer ends shall have the caps removed at least once every 18 months, and also whenever the United States inspector or the railroad company's inspector considers the removal desirable in order to thoroughly inspect the stay bolts. The fire box sheets should be examined carefully at least once a month to detect any bulging or indications of broken stay bolts.

STAY BOLT TESTING.

24. METHOD OF TESTING FLEXIBLE STAY BOLTS WITHOUT CAPS.— Flexible stay bolts which do not have caps shall be tested once each month, the same as rigid bolts.

Each time a hydrostatic test is applied, such stay bolt test shall be made while the boiler is under hydrostatic pressure not less than the allowed working pressure, and proper notation of such test made on Form No. 3.

NOTE.— To provide a proper service period between hydrostatic tests, removal of caps from flexible stay bolts and removal of flues for locomotives which are stored for an extended period, the time for performing such work on locomotives which are stored in good condition for one or more full calendar months may be extended without filing application, as follows:

Hydrostatic tests will be due after 12 months' service, provided such service is performed within 24 consecutive months.

Removal of caps from flexible stay bolts will be due after 18 months' service, provided such service is performed within 30 consecutive months.

Removal of flues will be due after three years' service, provided such service is performed within four consecutive years.

Time out of service must be properly covered by out-of-service reports and notation showing the months out of service on account of which the extension is claimed made on the back of inspection reports and cab cards.

No extension of time as provided above will be allowed for portions of a month.

If the locomotive is out of service when any of the above work is due, it need not be performed until just prior to the time the locomotive is returned to service.

25. BROKEN STAY BOLTS.— No boiler shall be allowed to remain in service when there are two adjacent stay bolts broken or plugged in any part of the fire box or combustion chamber, nor when three or more are broken or plugged in a circle 4 feet in diameter, nor when five or more are broken or plugged in the entire boiler.

26. TELLTALE HOLES.— All stay bolts shorter than 8 inches applied after July 1, 1911, except flexible bolts, shall have telltale holes three-sixteenths inch in diameter, and not less than 1¼ inches deep in the outer end. These holes must be kept open at all times.

27. All stay bolts shorter than 8 inches, except flexible bolts, and rigid bolts which are behind frames and braces, shall be drilled when the locomotive is in the shop for heavy repairs, and this work must be completed prior to July 1, 1914.

STEAM GAUGES.

28. LOCATION OF GAUGES.— Every boiler shall have at least one steam gauge which will correctly indicate the working pressure. Care must be taken to locate the gauge so that it will be kept reasonably cool, and can be conveniently read by the enginemen.

29. SIPHON.— Every gauge shall have a siphon of ample capacity to prevent steam entering the gauge. The pipe connection shall enter the boiler direct, and shall be maintained steam-tight between boiler and gauge.

The siphon pipe and its connections to the boiler must be cleaned each time the gage is tested.

30. Time of Testing.— Steam gauges shall be tested at least once every three months, and also when any irregularity is reported.

31. Method of Testing.— Steam gauges shall be compared with an accurate test gauge or dead-weight tester, and gauges found inaccurate shall be corrected before being put into service.

32. Badge Plates.—A metal badge plate showing the allowed steam pressure shall be attached to the boiler head in the cab. If boiler head is lagged, the lagging and jacket shall be cut away so the plate can be seen.

33. Boiler Number.—The builder's number of the boiler, if known, shall be stamped on the dome. If the builder's number of the boiler can not be obtained, an assigned number, which shall be used in making out specification card, shall be stamped on dome.

SAFETY VALVES.

34. Number and Capacity.— Every boiler shall be equipped with at least two safety valves, the capacity of which shall be sufficient to prevent, under any conditions of service, an accumulation of pressure more than 5 per cent above the allowed steam pressure.

Item 35. Setting of Safety Valves.— Safety valves shall be set to pop at pressures not exceeding 6 lb. above the working steam pressure. When setting safety valves, two steam gages shall be used, one of which must be so located that it will be in full view of the person engaged in setting such valves; and if the pressure indicated by the gages varies more than 3 lb. they shall be removed from the boiler, tested and corrected before the safety valves are set. Gages shall in all cases be tested immediately before the safety valves are set or any change made in the setting. When setting safety valves the water level in the boiler shall not be above the highest gage cock.

36. Time of Testing.— Safety valves shall be tested under steam at least once every three months, and also when any irregularity is reported.

WATER GLASS AND GAUGE COCKS.

37. Number and Location.— Every boiler shall be equipped with at least one water glass and three gauge cocks. The lowest gauge cock and the lowest reading of the water glass shall be not less than 3 inches above the highest part of the crown sheet. Locomotives which are not now equipped with water glasses shall have them applied on or before July 1, 1912.

38. Water-glass Valves.—All water glasses shall be supplied with two valves or shut-off cocks, one at the upper and one at the lower connection to the boiler, and also a drain cock, so constructed and located that they can be easily opened and closed by hand.

39. TIME OF CLEANING.—The spindles of all gauge cocks and water glass cocks shall be removed and cocks thoroughly cleaned of scale and sediment at least once each month.

40. All water glasses must be blown out and gauge cocks tested before each trip, and gauge cocks must be maintained in such condition that they can be easily opened and closed by hand without the aid of a wrench or other tool.

41. WATER AND LUBRICATOR GLASS SHIELDS.—All tubular water glasses and lubricator glasses must be equipped with a safe and suitable shield which will prevent the glass from flying in case of breakage, and such shield shall be properly maintained.

42. WATER-GLASS LAMPS.—All water glasses must be supplied with a suitable lamp properly located to enable the engineer to easily see the water in the glass.

INJECTORS.

43. Injectors must be kept in good condition, free from scale, and must be tested before each trip. Boiler checks, delivery pipes, feed-water pipes, tank hose and tank valves must be kept in good condition, free from leaks and from foreign substances that would obstruct the flow of water.

FLUE PLUGS.

44. Flue plugs must be provided with a hole through the center not less than three-fourths inch in diameter. When one or more tubes are plugged at both ends the plugs must be tied together by means of a rod not less than five-eighths inch in diameter. Flue plugs must be removed and flues repaired at the first point where such repairs can properly be made.

WASHING BOILERS.

45. TIME OF WASHING.—All boilers shall be thoroughly washed as often as the water conditions require, but not less frequently than once each month. All boilers shall be considered as having been in continuous service between washouts unless the dates of the days that the boiler was out of service are properly certified on washout reports and the report of inspection.

46. PLUGS TO BE REMOVED.—When boilers are washed all washout, arch and water-bar plugs must be removed.

47. WATER TUBES.— Special attention must be given the arch and water-bar tubes to see that they are free from scale and sediment.

48. OFFICE RECORD.—An accurate record of all locomotive boiler washouts shall be kept in the office of the railroad company. The following information must be entered on the day that the boiler is washed:

(a) Number ot locomotive.

(b) Date of washout.

(c) Signature of boiler washer or inspector.

(d) Statement that spindles of gauge cocks and water-glass cocks were removed and cocks cleaned.

(e) Signature of the boiler inspector or the employee who removed the spindles and cleaned the cocks.

STEAM LEAKS.

49. LEAKS UNDER LAGGING.— If a serious leak develops under the lagging, an examination must be made and the leak located. If the leak is found to be due to a crack in the shell or to any other defect which may reduce safety, the boiler must be taken out of service at once, thoroughly repaired and reported to be in satisfactory condition before it is returned to service.

50. LEAKS IN FRONT OF ENGINEMEN.—All steam valves, cocks and joints, studs, bolts and seams shall be kept in such repair that they will not emit steam in front of the enginemen so as to obscure their vision.

FILING REPORTS.

51. REPORT OF INSPECTION.— Not less than once each month and within ten days after each inspection, a report of Inspection, Form No. 1, size 6 by 9 inches, shall be filed with the district inspector of locomotive boilers for each locomotive used by a railroad company, and a copy shall be filed in the office of the chief mechanical officer having charge of the locomotive.

52. A copy of the monthly inspection report, Form No. 1, or annual inspection report, Form No. 3, properly filled out, shall be placed under glass in a conspicuous place in the cab of the locomotive before the boiler inspected is put into service.

53. Not less than once each year and within ten days after hydrostatic and other required tests have been completed, a report of such tests showing general condition of the boiler and repairs made shall be submitted on Form No. 3,* size 6 by 9 inches, and filed with the district inspector of locomotive boilers, and a copy shall be filed in the office of the chief mechanical officer having charge of the locomotive. The monthly report will not be required for the month in which this report is filed.

54. SPECIFICATION CARD.—A specification card, size 8 by 10½ inches, Form No. 4, containing the results of the calculations made in determining the working pressure and other necessary data, shall be filed in the office of the chief inspector of locomotive boilers for each locomotive boiler. A copy shall be filed in the office of the chief mechanical officer having charge of the locomotive. Every specification card shall be verified by the oath of the engineer making the calculations, and shall be approved by the chief mechanical officer. These specification cards shall be filed as promptly as thorough examination and accurate calculation will permit. Where accurate drawings of boilers are available, the data for specification card,

* Form No. 3 should be printed on yellow paper.

Form No. 4, may be taken from the drawings, and such specification cards must be completed and forwarded prior to July 1, 1912. Where accurate drawings are not available, the required data must be obtained at the first opportunity when general repairs are made, or when flues are removed. Specification cards must be forwarded within one month after examination has been made, and all examinations must be completed and specification cards filed prior to July 1, 1913, flues being removed if necessary to enable the examination to be made before this date.

When any repairs or changes are made which affect the data shown on the specification card, a corrected card or an alteration report on an approved form, size 8 by 10½ in., properly certified to, giving details of such changes, shall be filed within 30 days from the date of their completion. This report should cover:

(a) Application of new barrel sheets or domes.

(b) Application of patches to barrels or domes of boilers, or to portion of wrapper sheet of crowbar which is not supported by stay bolts.

(c) Longitudinal seam reinforcements.

(d) Changes in size or number of braces, giving maximum stress.

(e) Initial application of superheaters, arch or water bar tubes, giving number and dimensions of tubes.

(f) Changes in number or capacity of safety valves.

Report of patches should be accompanied by a drawing or blue-print of the patch, showing its location in regard to the center line of boiler, giving all necessary dimensions and showing the nature and location of the defect. Patches previously applied should be reported the first time boiler is stripped to permit an examination.

ACCIDENT REPORTS.

55. In the case of an accident resulting from failure, from any cause, of a locomotive boiler, or any of its appurtenances, resulting in serious injury or death to one or more persons, the carrier owning or operating such locomotive shall immediately transmit by wire to the chief inspector of locomotive boilers, at his office in Washington, D. C., a report of such accident, stating the nature of the accident, the place at which it occurred, as well as where the locomotive may be inspected, which wire shall be immediately confirmed by mail, giving a full, detailed report of such accident, stating, so far as may be known, the causes, and giving a complete list of the killed or injured.

METHOD OF CONDUCTING EFFICIENCY TESTS OF LOCOMOTIVES.

STANDARD.

In 1894 a method of conducting tests of locomotives was submitted by a committee of the Association, and on motion adopted as a standard of the Association. (See page 200, report 1894.) Revised in 1914.

The tests are as follows:

LABORATORY TESTS.

OBJECT.

The object of a laboratory test is to determine the steam and coal consumption per unit of power when the locomotive is operated under fixed conditions.

PREPARATIONS.

1. All driving wheels should be turned to same diameter and should be standard contour.

2. Each pair of driving wheels should be checked to see that they are correctly quartered for the crank pins.

3. If the locomotive selected has ever been through the shops for general repairs, the frames should be tried to see that they line with the cylinders.

4. The boiler tubes must be new or newly pieced, so as to be free from boiler sediment.

5. The steam cylinders should be approximately the same diameter and as near to that called for as standard for the class of locomotive, as practicable, and they should be bored if not in good condition. The piston packing rings should be in good condition.

6. On "D" valve type of locomotive the valves and seats should be faced, and on piston valve type old bushings should be bored if not in good condition, or new bushings applied.

7. Piston-valve packing rings should be examined and in good condition, after which a test pressure of at least 60 pounds should be applied to the steam pipes to determine that the throttle, steam pipes and exhaust passage are tight.

8. The front end arrangement for the locomotive should be carefully gone over and checked with the print in accordance with which the front end is supposed to have been applied.

9. The stack and draft pipe should be lined to determine that they are properly erected with reference to the exhaust nozzle.

10. Steam joints in the injector and delivery pipes should be tested to determine that they are steam tight.

11. The lift of the throttle valve should be determined for each live notch on the throttle-lever quadrant. When necessary, the cut-off should be taken for each notch on the reverse-lever rack.

12. The locomotive selected should reach the Locomotive Testing Laboratory at least four days prior to the time when it is scheduled to go under test, in order to permit the application of all instruments and to take the necessary measurements of various parts of the locomotive.

FUEL.

For efficiency tests of locomotives, a standard coal should be selected that can be easily obtained on short notice, and in accordance with the special object in view. If maximum efficiency or capacity is desired, the

coal should preferably be some kind that is regarded as a standard for the locality where the locomotive is operated.

When oil fuel is used, the rule governing the tests may be modified to conform to the characteristics of liquid fuel.

APPARATUS AND INSTRUMENTS.

The apparatus and instruments required for laboratory tests of a locomotive are as follows:

1. Platform scale for weighing coal and ash.
2. Tanks and scales for weighing water.
3. Graduated scale attached to water glass.
4. Pressure gages graduated to at least pounds for boiler, branch pipe, receiver, exhaust and at other points as is required.
5. Draft gages for smokebox, firebox and ashpan.
6. Thermometers for calorimeter, branch pipe, receiver and exhaust.
7. Pyrometers for firebox, smokebox and at other points as is required.
8. Steam calorimeter.
9. Steam cylinder indicators.
10. Some form of speed recorder to denote the revolutions of driving wheels.
11. Gas analysis apparatus.
12. Friction brake apparatus.
13. Dynamometer for determining the pull at drawbar.
14. Some form of indicator rigging.

In addition to the above, it will be necessary to have planimeters, micrometers, scales, calculating instruments, etc.

A calibration should be made by water glass method of both safety valves, and a correction made during a test.

The scales, gages, thermometers and pyrometers should be carefully calibrated at specified intervals.

APPLICATION OF INSTRUMENTS.

The pressure gages for boiler, branch pipe and exhaust should be connected with a long siphon and located at convenient points for the observers. Care should be taken to make correction for pressure should the gage be located so that the water head would affect the reading.

For taking temperature of steam in branch pipe and exhaust passage, thermometers should be inserted into wells, and given proper depth ot immersion.

The indicator reducing motion should be some form of pendulum type with light tube for transmitting the reduced motion to a point near the indicator. The pipes leading from the cylinder to the indicator should be not less than ½ inch inside diameter, and they should connect into the side of the cylinder rather than into the heads, thus making a very short connection. Short bends in the pipes should be avoided and they should be well lagged to prevent radiation.

A light framework should be secured to the cylinder to act as a brace for the indicators, and for the motion-rod supports. Absolute rigidity is highly essential in this particular.

Care should also be taken to set the indicators in such a position, that the finger on the end of the motion rod travels in a direction pointing to the groove in the drum proper. See Fig. 1.

Draft gages consisting of "U" tubes properly graduated in inches, containing water, should be placed at convenient locations, and connected at the smokebox or any other point at which the draft is taken, with a ¼-inch pipe. A rubber tube connection should be provided to connect the draft pipe with the "U" tube. In the smokebox the pipes should be located at the horizontal center line of boiler in front and back of diaphragm, with the end drilled in accordance with Fig. 2 at the vertical center line of the boiler.

The draft in the firebox should be taken through a drilled stay bolt, located at a point about half the length of the firebox and about 24 inches above the grates. The draft in the ashpan should be taken at some convenient point at about the center of the entire grate area.

The smokebox pyrometer or thermometer should be inserted so that the hot point or bulb is below the tip of the exhaust nozzle and in front of the table plate. If a thermometer is used for this purpose it should be graduated to 1,000 degrees.

The tube placed in the firebox for inserting the pyrometer should be located opposite the stay bolt drilled for the draft. This tube should be a piece of two-inch boiler tube and located on the center line of a stay bolt.

The gas sampling pipe should be located at the smallest area under the draft plate, and in the center of this area. This pipe should have numerous drilled holes equally spaced and the total area of the holes should not be more than the inside area of the sampling pipe as shown in Fig. 3.

A steam calorimeter should be attached either at the dome at a point close to the throttle valve, or to the branch pipe according as it is desired to obtain the quality of the steam at one point or the other. The former location is preferred. A perforated ½-inch pipe should be used for sampling and conveying the steam to the calorimeter as shown in Fig. 4.

OPERATING CONDITIONS.

In a laboratory test where maximum efficiency is the object in view, there should be uniformity in such matters as steam pressure, quantity of coal supplied at each firing, thickness of fire, and in other firing operations.

The rate of supplying the feed-water should be uniform through the entire test, and a certain level (about second gage cock), should be maintained from start to finish of test.

DURATION.

The duration of a laboratory test of a locomotive will depend upon the character of the fuel used, rate of combustion and working limitations

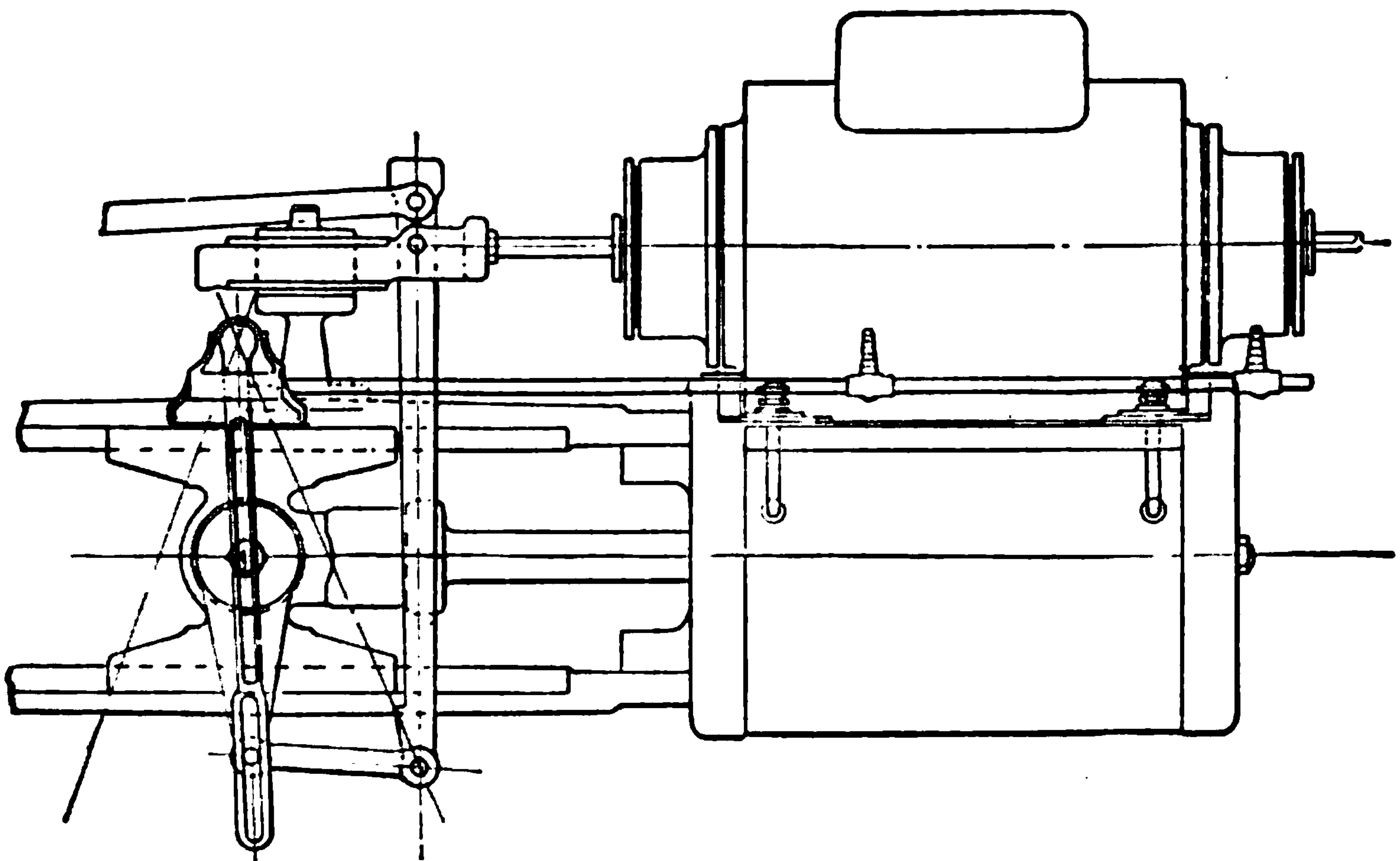


FIG. NO. 1.

INDICATOR REDUCING MOTION FOR LABORATORY TESTS.

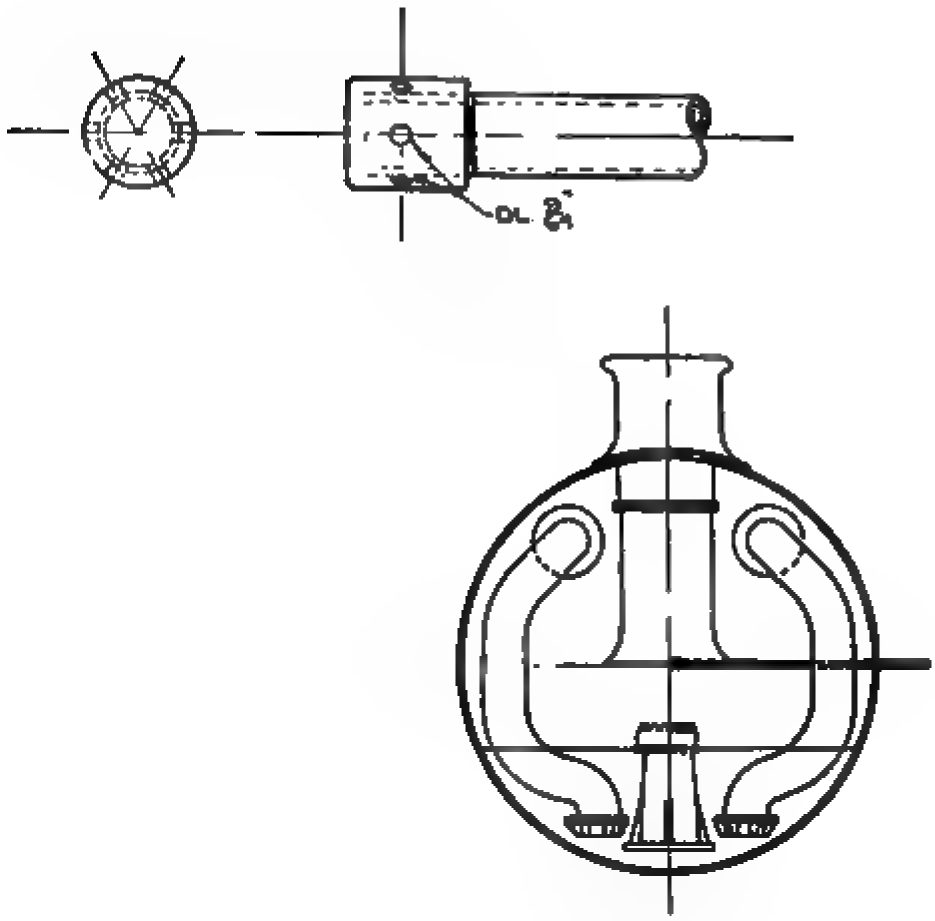


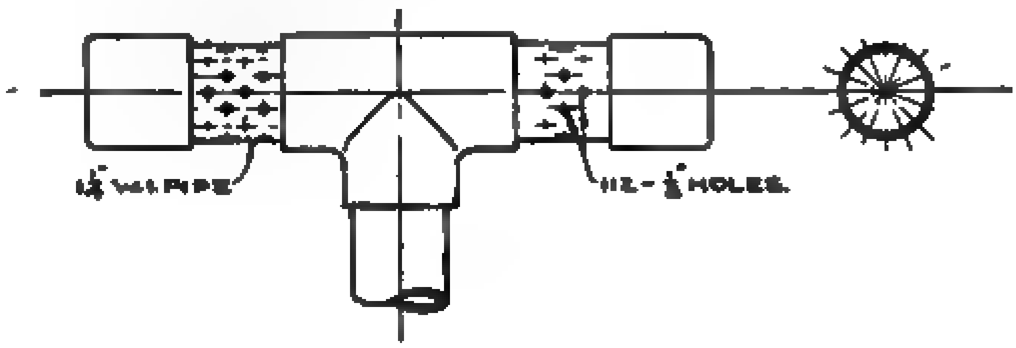
FIG. NO. 2.

LOCATION OF DRAFT PIPES FRONT &
BACK OF DIAPHRAGM

of the revolving parts. The test should preferably be continued until at least 25 pounds equivalent evaporation of water per square foot of heating surface have been obtained. If from the graphical log the coal and water performances are uniform, tests of three hours will be the limit.

STARTING AND STOPPING.

The fire having been thoroughly cleaned and banked when necessary to permit coking, previous to starting the test, the bank should be broken up and fresh fuel supplied. The locomotive should be started and run at the speed of the test a sufficient length of time to build up a level fire, and



LOCATION OF GAS SAMPLING PIPE.

which should be, as near as possible, so maintained throughout the test. When all conditions of fire and speed have become uniform, the thickness of the fire should be noted, but the starting signal for the beginning of the test proper should not be given until the locomotive has been run at least 10 minutes. Observe the steam pressure and time, and record the latter as the starting time of test. Water level should be maintained uniformly throughout the test. The ashpan should be cleaned at the starting signal.

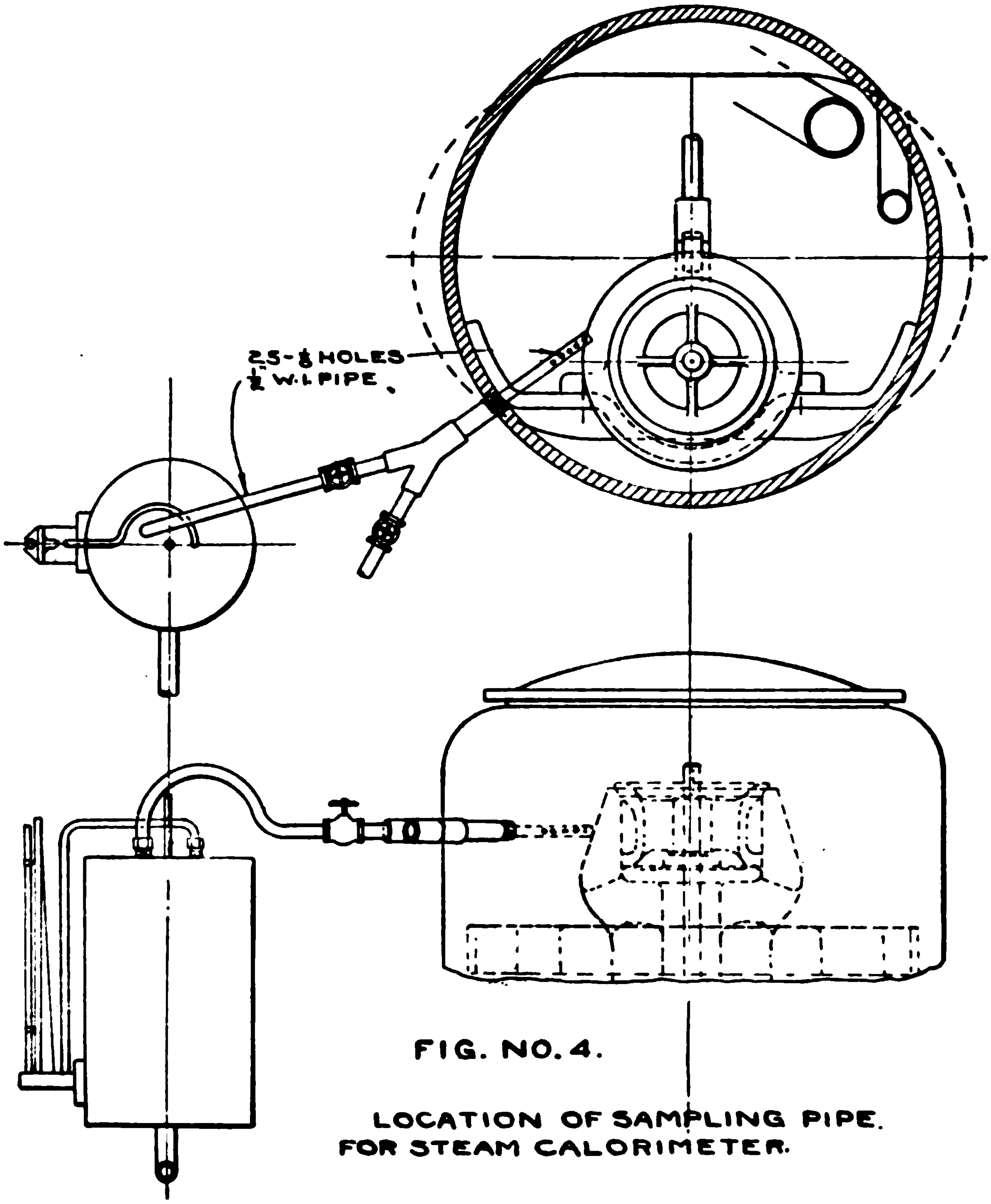


FIG. NO. 4.

LOCATION OF SAMPLING PIPE
FOR STEAM CALORIMETER.

When the end of the test approaches, the fire having been kept at a uniform thickness during the run, the time and water level should be noted and test stopped. When the test is completed the ashpan should be cleaned and cinders, if any, should be removed from the smokebox.

RECORDS.

A log of the data should be entered on printed forms and records taken at 10-minute intervals, unless a special test is in progress, when the readings may be taken more frequently. The coal should be weighed out in not less than 300-pound lots and the time taken for each lot burned.

Weighing tanks of sufficient capacity should be provided to maintain water in the supply, varying in head not more than six inches, and readings of the water used should be plotted upon the graphical logs at convenient regular intervals.

Indicator diagrams should be taken at the same periods the other data are taken.

A sufficient number of observers should be supplied in order that all important observations should be taken simultaneously.

At a laboratory where two tests are made each day, the number of men required is as follows:

	Number of Men.
Foreman of Testing Laboratory	1
Assistant Foreman of Testing Laboratory	1
Stenographer	1
Chemist	1
Computers	7
Brake Wheel Operator	1
Dynamometer Observer	1
Smoke Observer	1
Cab and Coal Observer	1
Temperature and Pressures	1
Speed, Boiler Pressure, Drafts and Pyrometers	1
Water Observer	1
Indicator Observers	2
Gas Sampler	1
Oilers	2
Engine Operator	1
Firemen	2
Draftsmen	3
Coal Passers and Janitors	3
Total	32

The force would have to be increased should a Mallet type of locomotive be tested.

All observers, operators, oilers and firemen should assist in dismantling and fitting up laboratory when locomotives are changed.

ASH AND REFUSE.

Ash and all the refuse withdrawn from the ashpan and smokebox at the end of the test should be weighed in a dry state, and if desired, sample taken for analysis of heating value and unburned carbon.

SAMPLING COAL.

If the coal to be tried is more than the amount necessary to make the test, it should be sampled according to the recommendations of the Committee of the American Chemical Society governing carload sampling, which are as follows: Six shovelfuls should be taken along each side and six across the center of the car. If the car is to be unloaded into bins, a small amount of coal should be taken off the conveyor buckets or wagons while the entire car is being unloaded. In all events the sample should not be less than 300 pounds, and after it is crushed and quartered about one quart should be taken and placed in an air-tight jar for chemical analysis.

On all tests the total moisture should be used in the calculations.

CALORIFIC TESTS OF COAL.

The analyses commonly made are what are termed "proximate" analyses; these consist in the determination of the following items:

Fixed carbon, per cent.
Volatile matter, per cent.
Moisture hydroscopic, per cent.
Moisture total, per cent.
Ash, per cent.
Sulphur separately, per cent.
B. t. u. per pound of fuel.

For complete determinations of the quality of coal, it is necessary to make an ultimate analysis, which requires the determination of the following additional items:

Carbon, per cent.
Hydrogen, per cent.
Nitrogen, per cent.
Oxygen by difference, per cent.

DATA AND RESULTS.

The data and results should be reported on forms in accordance with items given herewith.

DESCRIPTION, DIMENSIONS AND PROPORTIONS.

DRIVING WHEELS.

1. Number of pairs..
2. Nominal diameter, inches...
3. Measured circumference, feet, right No. 1........................
4. Measured circumference, feet, right No. 2........................
5. Measured circumference, feet, right No. 3........................
6. Measured circumference, feet, right No. 4........................
7. Measured circumference, feet, right No. 5........................
8. Measured circumference, feet, right No. 6........................
9. Measured circumference, feet, right No. 7........................
10. Measured circumference, feet, right No. 8........................
11. Measured circumference, feet, left No. 1........................
12. Measured circumference, feet, left No. 2........................
13. Measured circumference, feet, left No. 3........................
14. Measured circumference, feet, left No. 4........................
15. Measured circumference, feet, left No. 5........................
16. Measured circumference, feet, left No. 6........................
17. Measured circumference, feet, left No. 7........................
18. Measured circumference, feet, left No. 8........................
19. Average circumference, feet...
20. Average diameter, inches...
21. ....
22. ....
23. ....
24. ....
25. ....

ENGINE TRUCK WHEELS.

26. Number ....
27. Diameter, inches ....
28. ....
29. ....
30. ....
31. ....
32. ....

TRAILING WHEELS.

33. Diameter, inches ....
34. ....
35. ....
36. ....
37. ....
38. ....

WHEEL BASE.

39. Driving wheel base, front locomotive, in feet........................
40. Driving wheel base, rear locomotive, in feet........................
41. Total wheel base in feet..
42. Gage of wheels in inches..
43. ....
44. ....
45. ....
46. ....
47. ....

WEIGHT OF ENGINE, POUNDS.

(With water at second gage cock and normal fire.)

48. On truck ....
49. On first drivers..
50. On second drivers...
51. On third drivers..
52. On fourth drivers...
53. On fifth drivers..
54. On sixth drivers..
55. On seventh drivers..
56. On eighth drivers...
57. On trailers ....
58. ....
59. ....
60. ....
61. ....
62. ....
63. Total ....
64. Total on drivers..

CYLINDERS.

65. High pressure, number...
66. Low pressure, number..
67. Arrangement ....
68. Diameter, inches, high pressure, right..................................
69. Diameter, inches, high pressure, left ....
70. Diameter, inches, low pressure, right...................................
71. Diameter, inches, low pressure, left ....
72. ....
73. ....
74. ....
75. ....
76. ....

STROKE OF PISTON, INCHES.

77. High pressure, right ....
78. High pressure, left ....
79. Low pressure, right ....
80. Low pressure, left ....
81. ....
82. ....
83. ....
84. ....
85. ....

CLEARANCE, PER CENT OF PISTON DISPLACEMENT.

86. High pressure, right, head end ....
87. High pressure, right, crank end ....
88. High pressure, left, head end ....
89. High pressure, left, crank end ....
90. Low pressure, right, head end ....
91. Low pressure, right, crank end ....
92. Low pressure, left, head end ....
93. Low pressure, left, crank end ....
94. ....
95. ....
96. ....
97. ....
98. ....

RECEIVER, CUBIC FEET.

99. Volume, right side..
100. Volume, left side..
101. ....
102. ....
103. ....
104. ....
105. ....

STEAM PORTS, INCHES.

(For piston valves, the length equals the circumference of inside of bushing, minus the sum of the widths of bridges.)

106. High-pressure admission, right, head end, length ....
107. High-pressure admission, right, head end, width ....
108. High-pressure admission, right, crank end, length ....
109. High-pressure admission, right, crank end, width ....
110. High-pressure admission, left, head end, length ....
111. High-pressure admission, left, head end, width ....
112. High-pressure admission, left, crank end, length ....
113. High-pressure admission, left, crank end, width ....

114. Low-pressure admission, right, head end, length ....
115. Low-pressure admission, right, head end, width ....
116. Low-pressure admission, right, crank end, length ....
117. Low-pressure admission, right, crank end, width ....
118. Low-pressure admission, left, head end, length ....
119. Low-pressure admission, left, head end, width ....
120. Low-pressure admission, left, crank end, length ....
121. Low-pressure admission, left, crank end, width ....
122. High-pressure exhaust, right, length ....
123. High-pressure exhaust, right, width ....
124. High-pressure exhaust, left, length ....
125. High-pressure exhaust, left, width ....
126. Low-pressure exhaust, right, length ....
127. Low-pressure exhaust, right, width ....
128. Low-pressure exhaust, left, length ....
129. Low-pressure exhaust, left, width ....
130. ....
131. ....
132. ....
133. ....
134. ....

PISTON RODS, DIAMETER, INCHES.

135. High pressure, right ....
136. High pressure, left ....
137. Low pressure, right ....
138. Low pressure, left ....
139. ....
140. ....
141. ....
142. ....
143. ....

TAIL RODS, DIAMETER, INCHES.

144. High pressure, right ....
145. High pressure, left ....
146. Low pressure, right ....
147. Low pressure, left ....
148. ....
149. ....
150. ....
151. ....
152. ....

VALVES.

153. Type ....
154. Design ....
155. Balanced area in per cent of total..............................

156. Type of valve motion..
157. ....
158. ....
159. ....
160. ....
161. ....

GREATEST VALVE TRAVEL, INCHES.

162. High pressure, right ....
163. High pressure, left ....
164. Low pressure, right ....
165. Low pressure, left ....
166. ....
167. ....
168. ....
169. ....
170. ....

STEAM LAP OF VALVE, INCHES.

171. High pressure, right, head end ....
172. High pressure, right, crank end ....
173. High pressure, left, head end ....
174. High pressure, left, crank end ....
175. Low pressure, right, head end ....
176. Low pressure, right, crank end ....
177. Low pressure, left, head end ....
178. Low pressure, left, crank end ....
179. ....
180. ....
181. ....
182. ....
183. ....

EXHAUST LAP OF VALVE, INCHES.

184. High pressure, right, head end ....
185. High pressure, right, crank end ....
186. High pressure, left, head end ....
187. High pressure, left, crank end ....
188. Low pressure, right, head end ....
189. Low pressure, right, crank end ....
190. Low pressure, left, head end ....
191. Low pressure, left, crank end ....
192. ....
193. ....
194. ....
195. ....
196. ....

MISCELLANEOUS.

197. Cylinder lagging material..
198. Cylinder jacket material..
199. ....
200. ....
201. ....
202. ....
203. ....

BOILER.

204. Type ....
205. Outside diameter, first ring, inches..................................
206. ....
207. ....
208. ....
209. ....
210. ....

TUBES.

211. Number ....
212. Outside diameter, inches..
213. Thickness, inches ....
214. Length between tube sheets, inches.....................................
215. Total fire area, square feet..
216. Serve tubes, number of ribs..
217. Serve tubes, sq. in. of inside surface in one inch of length..........
218. Number of arch tubes...
219. Outside diameter, inches...
220. Total fire area of arch tubes, sq. ft.......................................
221. ....
222. ....

SUPERHEATER.

223. Type ....
224. Number of tubes..
225. Outside diameter, inches..
226. Inside diameter, inches..
227. Length of tubes, inches..
228. Steam area through units, square inches................................
229. ....
230. ....
231. ....
232. ....
233. ....

FIREBOX, INSIDE.

234. Length ....inches...............
235. Width ....inches...............

236. Depth front end............................inches................
237. Depth back end............................inches................
238. Volume ....cubic feet............
239. ....
240. ....
241. ....
242. ....
243. ....

FIRE DOORS.

244. Number ....
245. Area, square feet..
246. Hand or automatic operated..
247. ....
248. ....
249. ....
250. ....

GRATES.

251. Style ....
252. Total area, square feet..
253. Total area dead grates, square feet..
254. Width of air space, inches..
255. Width of grates, inches..
256. Length of grates, inches..
257. ....
258. ....
259. ....

AIR INLETS.

260. Through firebox sides..................................square feet
261. Through grates ....square feet
262. Through fire door..................................square feet
263. Total air inlets, No. 260, No. 261 and No. 262............square feet
264. Ratio air inlets (No. 261) to grate area (No. 252)................
265. Ratio air inlets (No. 263) to grate area (No. 252)................
266. ....
267. ....
268. ....
269. ....
270. ....

HEATING SURFACE, SQUARE FEET.

271. Of the tubes, water side..
272. Of the tubes, fire side..
273. Of firebox, fire side..

274. Of superheater, fire side...
275. Total based on inside of firebox, fire side of water and superheater tubes, arch pipes and superheater, sq. ft.......................
276. Total based on inside of firebox, water side of water and superheater tubes, arch pipes and fire side of superheater, sq. ft.....
277. ....
278. ....
279. ....
280. ....
281. ....

BOILER VOLUMES.

(With water surface at level of second gage cock.)

282. Water space, cubic feet...
283. Steam space, cubic feet...
284. ....
285. ....
286. ....
287. ....
288. ....

EXHAUST NOZZLE.

289. Type ....
290. Dimensions of right side, inches..................................
291. Dimensions of left side, inches...................................
292. Area of right side, square inches.................................
293. Area of left side, square inches..................................
294. Total area ....
295. ....
296. ....
297. ....
298. ....
299. ....

REVERSE LEVER.

300. High-pressure cylinder, notches forward of center.................
301. Low-pressure cylinder, notches forward of center..................
302. ....
303. ....
304. ....
305. ....
306. ....

RATIO.

307. Heating surface (No. 275) to grate area (No. 252).................
308. Fire area through tubes (No. 215) to grate area (No. 252).........
309. Firebox heating surface (No. 273) to grate area (No. 252).........

310. Tube surface (No. 272) to firebox heating surface (No. 273)........
311. Firebox volume (No. 238) to grate area (No. 252).................
312. Superheater, length of units (No. 227) to internal diameter (No. 226) ....
313. ....
314. ....
315. ....
316. ....
317. ....

CONSTANTS.

318. For dynamometer horse-power (power developed when the speed is one r. p. m. and the pull is one pound).........................

For indicated horse-power (power developed at one r. p. m. and one pound m. e. p.)...

319. High-pressure cylinder, right, head end ....
320. High-pressure cylinder, right, crank end ....
321. High-pressure cylinder, left, head end ....
322. High-pressure cylinder, left, crank end...........................
323. Low-pressure cylinder, right, head end ....
324. Low-pressure cylinder, right, crank end ....
325. Low-pressure cylinder, left, head end ....
326. Low-pressure cylinder, left, crank end ....
327. ....
328. ....
329. ....
330. ....
331. ....

FOR PISTON DISPLACEMENT, CUBIC FEET.

332. High-pressure cylinder, right, head end ....
333. High-pressure cylinder, right, crank end ....
334. High-pressure cylinder, left, head end ....
335. High-pressure cylinder, left, crank end ....
336. Low-pressure cylinder, right, head end ....
337. Low-pressure cylinder, right, crank end ....
338. Low-pressure cylinder, left, head end ....
339. Low-pressure cylinder, left, crank end ....
340. ....
341. ....
342. ....
343. ....
344. ....

OBSERVED DATA.

345. Duration of test, hours...
346. Hand or stoker fired..

347. ....
348. ....
349. ....
350. ....

SPEED.

351. Total revolutions ....
352. Average ....Per minute..................
353. Equivalent speed in miles per hour............................
354. Equivalent piston speed in feet per minute......................
355. ....
356. ....
357. ....
358. ....
359. ....

POSITION OF LEVERS.

360. Reverse lever notches from front end.............................
361. ....
362. ....
363. Throttle lever ....
364. ....
365. ....

TEMPERATURE, DEGREES FAHRENHEIT.

366. Of smokebox, by thermometer ....
367. Of smokebox, by pyrometer ....
368. Of laboratory, dry bulb ....
369. Of laboratory, wet bulb ....
370. Of steam in branch pipe ....
371. Of steam in receiver ....
372. Of steam in exhaust passage ....
373. Of feed-water ....
374. Of firebox, by pyrometer.......................................
375. ....
376. ....
377. ....
378. ....
379. ....

PRESSURE, POUNDS PER SQUARE INCH.

380. In boiler, average ....
381. In boiler, maximum ....
382. In boiler, minimum ....
383. In branch pipe ....
384. In H. P. cylinder..
385. In L. P. cylinder..

386. In receiver ....
387. In exhaust passage ....
388. In laboratory, barometric ....
389. ....
390. ....
391. ....
392. ....
393. ....

DRAFT, INCHES OF WATER.

394. In smokebox, front of diaphragm.........................
395. In smokebox, back of diaphragm..........................
396. In firebox ....
397. In ashpan ....
398. ....
399. ....
400. ....
401. ....
402. ....

INJECTORS.

Hours in action.

403. Total right ....
404. Total left ....
405. Number times on right ....
406. Number times on left....................................

QUALITY OF STEAM.

407. In dome ....
408. In branch pipe ....
409. Degrees of superheat in branch pipe ....
410. Degrees of superheat in receiver ....
411. Degrees of superheat in exhaust ....
412. Factor of correction for quality of steam...............
413. ....
414. ....
415. ....
416. ....

COAL, SPARKS AND ASH.

417. Coal fired, kind ....
418. Coal fired, total ....
419. Dry coal fired, total.............pounds.................
420. Combustible, by analysis, total.........................
421. Ash, by analysis, total.................................
422. Cinders collected in smokebox, total....................
423. Sparks discharged from stack, total.....................

424. Cinders and sparks, total..................................
425. Coal loss due to steam loss, pounds per hour......................
426. Spark loss, per cent of total coal fired............................
427. ....
428. ....
429. ....
430. ....

SMOKE.

431. Ringelmann chart, per cent..
432. ....
433. ....
434. ....
435. ....
436. ....

ANALYSIS OF COAL (PROXIMATE).

437. Fixed carbon ....per cent................
438. Volatile matter ....per cent................
439. Moisture, hydroscopic ....per cent................
440. Moisture, total ....per cent................
441. Ash ....per cent................
442. Sulphur, determined separately............per cent................
443. B. t. u. per pound of fuel...
444. ....
445. ....
446. ....
447. ....
448. ....

ANALYSIS OF COAL (ULTIMATE).

449. Carbon per cent...
450. Hydrogen, per cent..
451. Nitrogen, per cent..
441. Ash, per cent...
442. Sulphur, per cent...
452. Oxygen by difference, per cent..............................
453. ....
454. ....
455. ....
456. ....
457. ....

CALORIFIC VALUE IN B. T. U. PER POUND.

458. Of dry coal...
459. Of combustible ....

460. Of cinders and sparks..
461. ....
462. ....
463. ....
464. ....
465. ....

ANALYSIS OF SMOKEBOX GASES.

466. Oxygen — O..............................per cent................
467. Carbon monoxide — CO...................per cent................
468. Carbon dioxide — CO_2....................per cent................
469. Nitrogen — N..............................per cent................
470. Hydrogen — H..............................per cent................
471. ....
472. ....
473. ....
474. ....
475. ....

WATER IN POUNDS.

476. Delivered to injectors..
477. Lost, from boilers ....
478. Lost, from ....
479. Lost, from ....
480. Lost, total ....
481. Delivered to boiler and presumably evaporated....................
482. ....
483. ....
484. ....
485. ....
486. ....

DYNAMOMETER.
Pull in Pounds.

487. Average ....
488. Maximum ....
489. Minimum ....
490. ....
491. ....
492. ....
493. ....
494. ....

CUT-OFF, PER CENT OF STROKE.

495. High-pressure cylinder, right, head end ....
496. High-pressure cylinder, right, crank end ....
497. High-pressure cylinder, left, head end ....

498. High-pressure cylinder, left, crank end............................
499. Average ....
500. Low-pressure cylinder, right, head end ....
501. Low-pressure cylinder, right, crank end ....
502. Low-pressure cylinder, left, head end ....
503. Low-pressure cylinder, left, crank end ....
504. Average ....
505. ....
506. ....
507. ....
508. ....
509. ....

RELEASE, PER CENT OF STROKE.

510. High-pressure cylinder, right, head end ....
511. High-pressure cylinder, right, crank end ....
512. High-pressure cylinder, left, head end ....
513. High-pressure cylinder, left, crank end ....
514. Average ....
515. Low-pressure cylinder, right, head end ....
516. Low-pressure cylinder, right, crank end ....
517. Low-pressure cylinder, left, head end ....
518. Low-pressure cylinder, left, crank end ....
519. Average ....
520. ....
521. ....
522. ....
523. ....
524. ....

BEGINNING OF COMPRESSION, PER CENT OF STROKE.

525. High-pressure cylinder, right, head end ....
526. High-pressure cylinder, right, crank end ....
527. High-pressure cylinder, left, head end ....
528. High-pressure cylinder, left, crank end ....
529. Average ....
530. Low-pressure cylinder, right, head end ....
531. Low-pressure cylinder, right, crank end ....
532. Low-pressure cylinder, left, head end ....
533. Low-pressure cylinder, left, crank end ....
534. Average ....
535. ....
536. ....
537. ....
538. ....
539. ....

PRESSURE FROM INDICATOR CARDS.

Initial pressures, pounds per square inch.

540. High-pressure cylinder, right, head end ....
541. High-pressure cylinder, right, crank end ....
542. High-pressure cylinder, left, head end ....
543. High-pressure cylinder, left, crank end ....
544. Average ....
545. Low-pressure cylinder, right, head end ....
546. Low-pressure cylinder, right, crank end ....
547. Low-pressure cylinder, left, head end ....
548. Low-pressure cylinder, left, crank end ....
549. Average ....
550. ....
551. ....
552. ....
553. ....
554. ....

STEAM-CHEST PRESSURES, POUNDS PER SQUARE INCH.

555. High pressure, right side ....
556. High pressure, left side ....
557. Average ....
558. Low pressure, right side ....
559. Low pressure, left side ....
560. Average ....
561. ....
562. ....
563. ....
564. ....
565. ....

PRESSURES AT CUT-OFF, POUNDS PER SQUARE INCH.

566. High-pressure cylinder, right, head end ....
567. High-pressure cylinder, right, crank end ....
568. High-pressure cylinder, left, head end ....
569. High-pressure cylinder, left, crank end ....
570. Average ....
571. Low-pressure cylinder, right, head end ....
572. Low-pressure cylinder, right, crank end ....
573. Low-pressure cylinder, left, head end ....
574. Low-pressure cylinder, left, crank end ....
575. Average ....
576. ....
577. ....
578. ....
579. ....
580. ....

PRESSURE AT RELEASE, POUNDS PER SQUARE INCH.

581. High-pressure cylinder, right, head end ....
582. High-pressure cylinder, right, crank end ....
583. High-pressure cylinder, left, head end ....
584. High-pressure cylinder, left, crank end ....
585. Average ....
586. Low-pressure cylinder, right, head end ....
587. Low-pressure cylinder, right, crank end ....
588. Low-pressure cylinder, left, head end ....
589. Low-pressure cylinder, left, crank end ....
590. Average ....
591. ....
592. ....
593. ....
594. ....
595. ....

PRESSURE AT BEGINNING OF COMPRESSION, POUNDS PER SQUARE INCH.

596. High-pressure cylinder, right, head end ....
597. High-pressure cylinder, right, crank end ....
598. High-pressure cylinder, left, head end ....
599. High-pressure cylinder, left, crank end ....
600. Average ....
601. Low-pressure cylinder, right, head end ....
602. Low-pressure cylinder, right, crank end ....
603. Low-pressure cylinder, left, head end ....
604. Low-pressure cylinder, left, crank end ....
605. Average ....
606. ....
607. ....
608. ....
609. ....
610. ....

LEAST BACK PRESSURE, POUNDS PER SQUARE INCH.

611. High-pressure cylinder, right, head end ....
612. High-pressure cylinder, right, crank end ....
613. High-pressure cylinder, left, head end ....
614. High-pressure cylinder, left, crank end ....
615. Average ....
616. Low-pressure cylinder, right, head end ....
617. Low-pressure cylinder, right, crank end ....
618. Low-pressure cylinder, left, head end ....
619. Low-pressure cylinder, left, crank end ....

620. Average ....
621. ....
622. ....
623. ....
624. ....
625. ....

SUMMARY OF AVERAGE RESULTS.

BOILER.

626. Dry coal fired, per hour ....pounds................
627. Dry coal fired, per hour per sq. ft. of grate surface, pounds........
628. ....
629. ....
630. ....
631. ....
632. ....

EVAPORATION, POUNDS.

633. Moist steam, per hour.......................................
634. Dry steam, per hour ....
635. Dry steam, per hour, per sq. ft. of heating surface................
636. Dry steam, per pound of dry coal ....
637. Dry steam, per pound of fuel as fired ....
638. Water loss — calorimeter, safety valves, stoker engine, jets, etc., pounds per hour.......................................
639. Dry steam to engines per hour..................................
640. Factor of evaporation...
641. ....
642. ....
643. ....
644. ....

EQUIVALENT EVAPORATION FROM AND AT 212° F.

645. Per hour ....
646. Per hour, boiler, excluding superheater..........................
647. Per hour, superheater alone ....
648. Per hour, per sq. ft. of total fire heating surface..................
649. Per hour, per sq. ft. of total heating surface, excluding superheater.
650. ....
651. ....
652. ....
653. ....
654. ....
655. Per hour, per sq. ft. of total heating surface, superheater alone.......

656. Per hour, per sq. ft. of grate area..............................
657. Per pound of coal as fired..............................
658. Per pound of dry coal ....
659. Per pound of combustible ....
660. Boiler horse-power ....
661. ....
662. ....
663. ....
664. ....
665. ....
666. Efficiency of boiler, based on fuel..............................
667. Efficiency of boiler per sq. ft. of heating surface ....
668. Efficiency of boiler per sq. ft. of grate surface ....
669. ....
670. ....
671. ....
672. ....
673. ....

SUMMARY OF AVERAGE RESULTS, ENGINE.

Mean effective pressure, pounds per square inch.

674. High-pressure cylinder, right, head end ....
675. High-pressure cylinder, right, crank end ....
676. High-pressure cylinder, left, head end ....
677. High-pressure cylinder, left, crank end ....
678. Average ....
679. Low-pressure cylinder, right, head end ....
680. Low-pressure cylinder, right, crank end ....
681. Low-pressure cylinder, left, head end ....
682. Low-pressure cylinder, left, crank end ....
683. Average ....
684. ....
685. ....
686. ....
687. ....
688. ....

RECEIVER.

689. Pressure, right side ....
690. Pressure, left side ....
691. Average ....
692. ....
693. ....
694. ....
695. ....
696. ....

NUMBER OF EXPANSIONS.

697. Right side, head end ....
698. Right side, crank end ....
699. Left side, head end ....
700. Left side, crank end ....
701. Total ....
702.. ....
703.. ....
704.. ....
705.. ....
706.. ....

INDICATED HORSE-POWER.

707. High-pressure cylinder, right, head end ....
708. High-pressure cylinder, right, crank end ....
709. High-pressure cylinder, left, head end ....
710. High-pressure cylinder, left, crank end ....
711. Total ....
712. Low-pressure cylinder, right, head end ....
713. Low-pressure cylinder, right, crank end ....
714. Low-pressure cylinder, left, head end ....
715. Low-pressure cylinder, left, crank end ....
716. Total ....
717. ....
718. ....
719. ....
720. ....
721. ....

DIVISION OF POWER.

722. High-pressure cylinder, right side ....
723. High-pressure cylinder, left side ....
724. Low-pressure cylinder, right side ....
725. Low-pressure cylinder, left side ....
726. Right side, total ....
727. Left side, total ....
728. Total ....
729. ....
730. ....
731. ....
732. ....
733. ....

PER I. H. P. HOUR.

734. Dry coal, pounds ....
735. B. t. u. in fuel ....

736. Dry steam, pounds..
737. B. t. u. in steam..
738. ....
739. ....
740. ....
741. ....
742. ....

SUMMARY OF AVERAGE RESULTS, LOCOMOTIVE.

743. Dynamometer horse-power ....
744. Dry coal per D. H. P. hour, lbs..
745. Dry steam per D. H. P. hour, lbs..
746. B. t. u. per D. H. P. hour..
747. ....
748. ....
749. ....
750. ....
751. ....

PER ONE MILLION FOOT-POUNDS AT DRAWBAR.

752. Dry coal, pounds ....
753. Dry steam, pounds ....
754. B. t. u..
755. I. H. P. per sq. ft. of heating surface ....
756. I. H. P. per sq. ft. of grate surface ....
757. D. H. P. per sq. ft. of heating surface ....
758. D. H. P. per sq. ft. of grate surface ....
759. ....
760. ....
761. ....
762. ....
763. ....
764. Tractive power, based on M. E. P. pounds..
765. ....
766. ....
767. ....
768. ....
769. ....

MACHINE FRICTION OF LOCOMOTIVE, IN TERMS OF

770. Horse-power ....
771. M. E. P. pounds..
772. Drawbar pull, pounds..
773. ....
774. ....

775. ....
776. ....
777. ....

EFFICIENCY.

778. Machine efficiency of locomotive, per cent ....
779. Thermal efficiency of locomotive (based on fuel), per cent..........
780. ....
781. ....
782. ....
783. ....
784. ....

RATIOS.

785. Total weight of locomotive to maximum I. H. P..................
786. Total heating surface to maximum I. H. P.........................
787. ....
788. ....
789. ....
790. ....
791. ....
792. Test number ....

SUMMARIZED STATEMENT OF AVERAGE RESULTS.

792. Test No. ....
345. Duration of tests, hours..
352. Number of revolutions per minute...................................
353. Speed, in miles per hour..
363. Throttle opening, full or partial....................................
499. Actual cut-off, per cent, H. P. cylinders...........................
504. Actual cut-off, per cent, L. P. cylinders...........................
294. Area of exhaust nozzle.....................sq. in.................
380. Boiler pressure, lbs. per sq. in......................................
383. Branch pipe pressure, lbs. per sq. in...............................
386. Receiver pressure, lbs. per sq. in....................................
387. Exhaust pressure, lbs. per sq. in....................................
615. Average least back pressure, lbs. H. P. cylinder...................
620. Average least back pressure, lbs. L. P. cylinder...................
409. Superheat in branch pipe — Degrees, Fahr........................
410. Superheat in receiver ....
411. Superheat in exhaust ....
394. Draft in front of diaphragm, inches of water.......................
395. Draft in back of diaphragm, inches of water.......................
396. Draft in firebox, inches of water...................................
397. Draft in ashpan, inches of water...................................
458. Calorific value of dry fuel, B. t. u. per pound.......................
626. Dry fuel fired per hour, lbs. ....

627. Dry fuel fired per hour per sq. ft. of grate, lbs..................
633. Water delivered to boiler, lbs. per hour..........................
645. Equivalent evaporation from and at 212°, lbs. per hour ....
648. Equivalent evaporation from and at 212°, lbs. per hour per sq. ft. of total fire heating surface....................................
658. Equivalent evaporation from and at 212°, lbs. per hour per pound of dry fuel...
660. Boiler horse-power (34.5 U of E)...............................
666. Efficiency of boiler, based on fuel...............................
431. Average smoke, per cent...
639. Dry steam to engines, lbs. per hour...............................
728. Indicated horse-power ....
734. Dry fuel per I. H. P. hour, lbs...................................
736. Dry steam per I. H. P. hour, lbs..................................
487. Drawbar pull, lbs...
743. Dynamometer or drawbar horse-power...........................
744. Dry fuel per D. H. P. hour......................................lbs.
745. Dry steam per D. H. P. hour.....................................lbs.
778. Machine efficiency of locomotive ....per cent.
779. Thermal efficiency of locomotive, based on fuel............per cent.

ROAD TESTS.

OBJECT.

The object of a road test is to determine the steam and coal consumption of a locomotive per unit of power under practical conditions of the locomotive in railroad service.

PREPARATIONS.

All of the preparations as given in laboratory tests should be carried out preparatory to placing the locomotive in service, with the possible exception of not having all driving wheels newly turned, and equipping the locomotive with the various instruments that can be done while the locomotive is in the shops for repairs.

FUEL.

The same consideration should be given to the fuel as on a laboratory test.

To facilitate the measurement of coal and the determination of the quantity used during any desired period of the run, it is desirable to provide sufficient number of sacks, of a size holding 100 pounds, and to weigh the coal into these sacks preparatory to starting on the test.

APPARATUS AND INSTRUMENTS.

The apparatus and instruments required for a road test of a locomotive are as follows:

No. 1. Platform scale for weighing coal.

No. 2. Crane, spring balance and bucket for weighing ash.

No. 3. Tank and scales for calibrating the tank.

No. 4. Graduated scale attached to water glass on boiler.

No. 5. Float for measuring height of water in tank, or, if preferred, graduated scales on all four corners of the tank.

No. 6. Pressure gages graduated to pounds for boiler, branch pipe, receiver and exhaust.

No. 7. Draft gages for smokebox, firebox and ashpan.

No. 8. Thermometers for calorimeter, branch pipe, receiver and exhaust.

No. 9. Pyrometers for firebox, smokebox, and at other points as required.

No. 10. Air-pump counters.

No. 11. Water meters.

No. 12. Steam calorimeter.

No. 13. Steam-cylinder indicators.

No. 14. Some form of speed recorder for the revolutions for the driving wheels in case no dynamometer is accessible. On Mallet type of locomotives two recorders should be used.

No. 15. Some form of pendulum indicator rigging.

No. 16. Traction dynamometer for determining pull at drawbar, with its complete equipment.

No. 17. Electrical connection between locomotive and dynamometer.

In addition to the above it will be necessary to have planimeters, micrometers, scales and calculating machines, etc.

Steam used for auxiliary purposes other than the cylinders, such as air pump, calorimeter, injector overflow, train lighting and heating and what escapes from the safety valves, may be estimated from data obtained by testing them either before or after the trial.

The scales, gages and pyrometers should be calibrated before and after the tests are made.

APPLICATION OF INSTRUMENTS.

All of the instruments given under laboratory test should be carried on road tests as far as practicable, with a few exceptions.

The indicator rig should be some form of pendulum motion with a light tube for transmitting the reduced motion to a point near the indicator. See Fig. 5.

The apparatus which is most suitable consists of a three-way cock for the attachment of the indicator, with a **steam-chest** connection, so that diagrams can be drawn on each cylinder card and pressures determined.

The three-way cock should be provided with a clamp rigidly secured to the cylinder and thus overcome any tendency of the indicator to move longitudinally with reference to the driving rig. The support for the motion rod should be secured to some point on the steam chest. Care

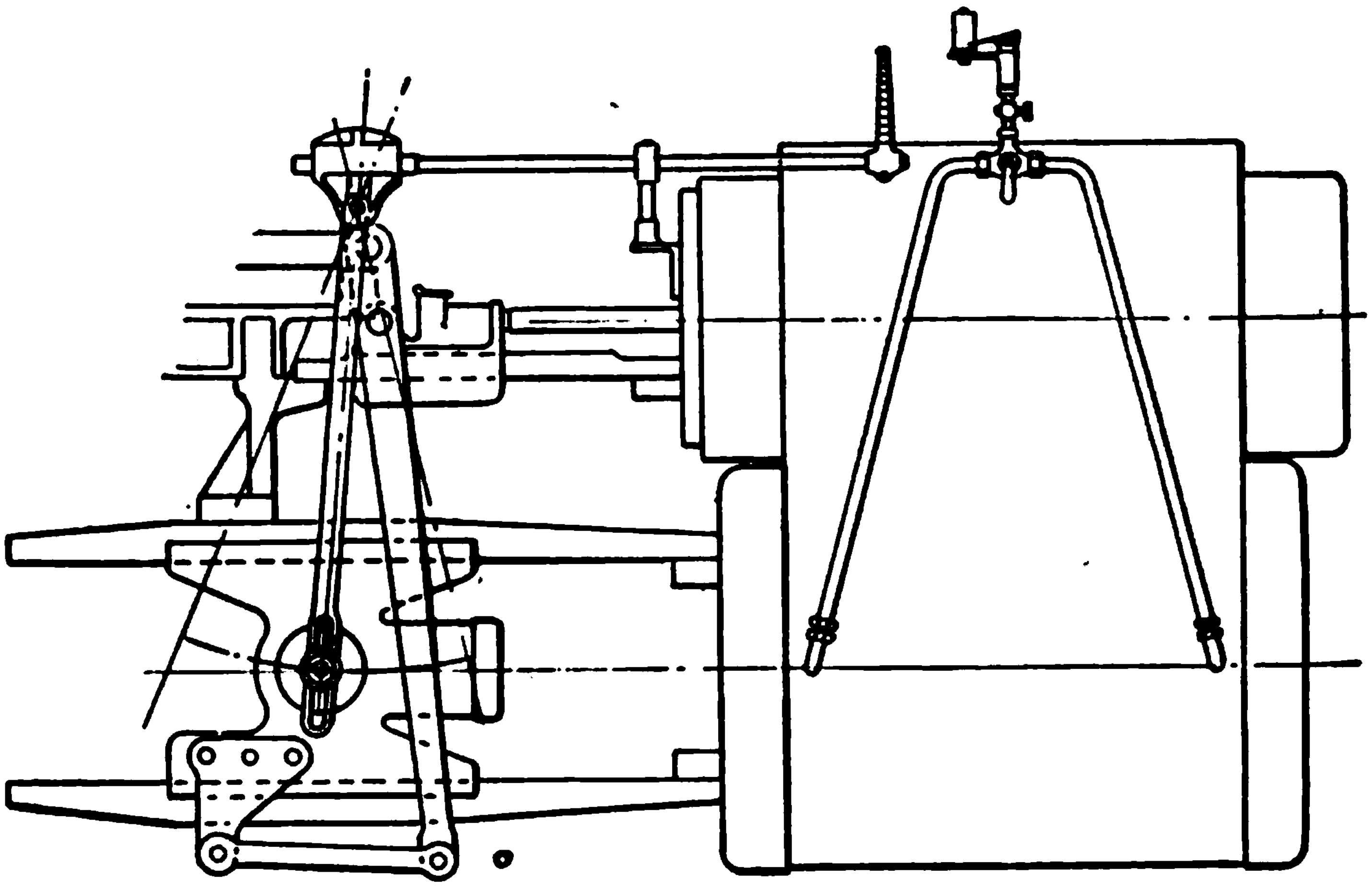


FIG. NO. 5.

INDICATOR REDUCING MOTION FOR ROAD TESTS.

should be taken to set the indicators in such a position that the finger on the end of the motion rod travels in a direction pointing to a groove in the drum proper.

The pipes leading from the cock to the cylinder should be not less than ½ inch inside diameter, and if possible not exceeding 36 inches in length. They should be connected into the side of the cylinder, rather than into the heads. Sharp bends in the pipe should be avoided and they should be well lagged to reduce radiation.

If a dynamometer car is not used, stroke counter should be placed at some convenient point in the pilot box to record the revolutions of the drivers. This can be conveniently driven from a finger on the motion rod of the indicator rigging.

To facilitate the working of the men who operate the indicators and read the instruments at the front of the locomotive, and to protect them from wind or rain and jolting, a suitable pilot box extending back to the cylinder and properly secured to the bumper beam should be provided. See Fig. 6.

Whenever practicable, the bulbs of the thermometers used in branch pipe, receiver or exhaust should come in direct contact with the steam and no wells used. When thermometers are placed in wells, they do not respond quickly with the different changes in the working of the locomotive.

The water meters should be attached to the suction pipes of the injectors, and located at points where they can be conveniently read while the locomotive is in motion. Each meter should be provided with a check valve to prevent hot water from flowing through them from the injectors, and strainers to intercept foreign material. With the water scoops it will be impossible to use a float, but when tests are made on roads not using water scoops, a suitable float should be made for determining the water consumption. The water level may be established by using a rubber hose with glass tube inserted in the end, which will indicate the height of water in the tank, this tube to be brought in contact with a properly calibrated scale, or, if more convenient, long glass tubes may be provided at each corner of the tank for the same purpose.

In all cases the term "branch pipe" refers to the steam-supply pipe to the cylinders and not the injector branch pipe.

OPERATING CONDITIONS.

The same operating conditions should be maintained as far as practicable as on a laboratory test.

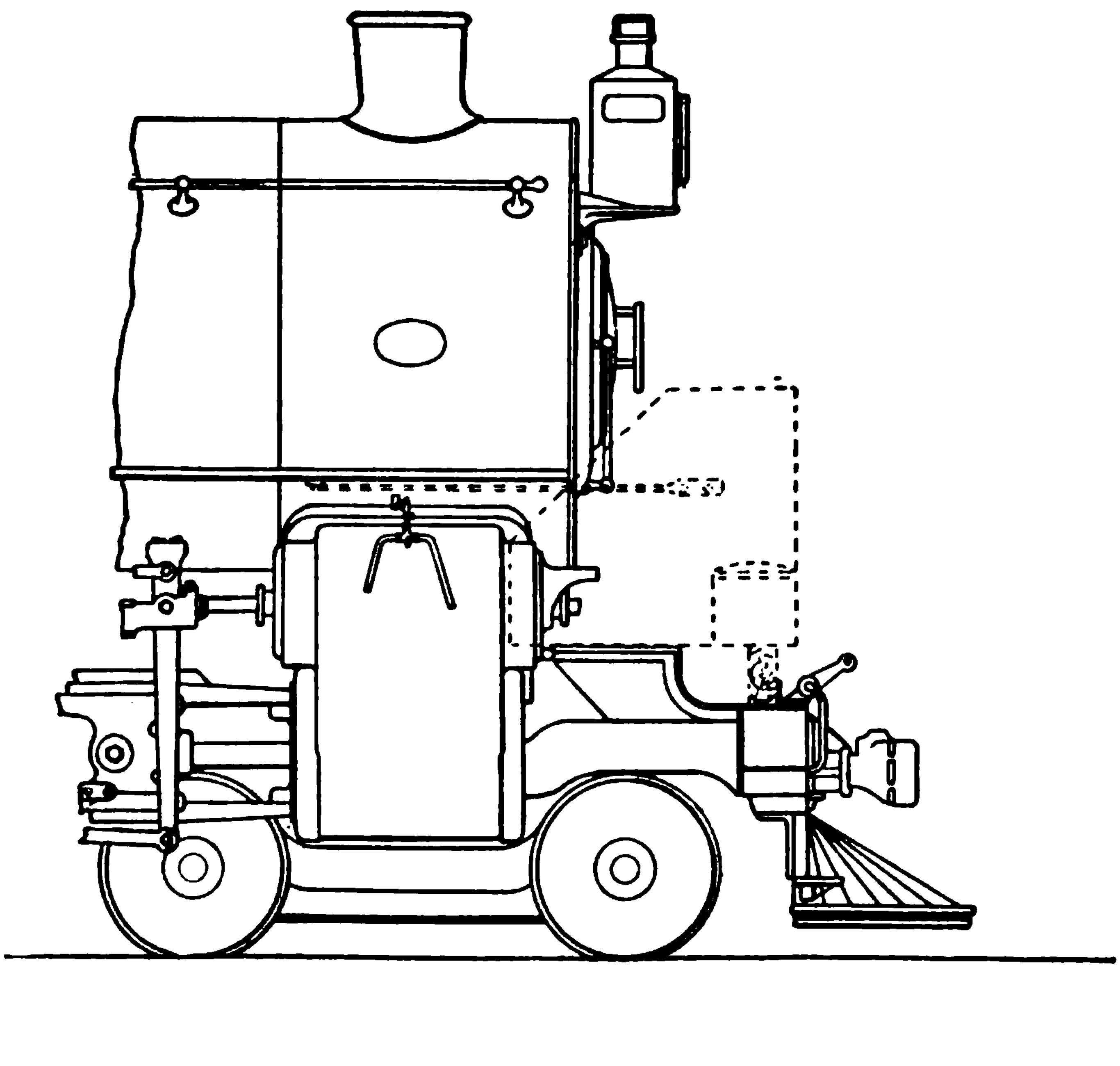


FIG. NO. 6

TYPE OF PILOT BOX FOR ROAD TESTS.

DURATION.

The duration of a test is the running time minus time the throttle is closed, and depends upon the length of the run between locomotive terminals. In fast passenger service the runs should be, if practicable, at least 100 miles long. In service requiring frequent stops and in freight service, the distance may be much shorter. The length of time upon which the hourly rates of consumption and evaporation are based is the total time that the throttle valve is open and not elapsed time between the starting and stopping times.

STARTING AND STOPPING.

The fire having been thoroughly cleaned, banked to permit coking, fresh fuel should be supplied to a level thickness which will be required for the run. After the locomotive is attached to the train, observe the pressure, the water level or meter readings, and when the locomotive starts take this as the starting time. Thereafter cover the fire with weighed coal and proceed with the regular work of the test. The ashes and refuse should be removed from the ashpan and smokebox before the locomotive is coupled to the train.

During the run the fire should be maintained in as equal and uniform condition as practicable, and when the end of the route is reached the fire should be as level and approximately the same thickness and condition as at the start. When the locomotive is stopped and the proper level of the fire obtained, the weighed coal should be discontinued. If during the run a stop of over seven minutes is made, and in order to keep the fire in proper condition fresh fuel must be supplied, this should be selected from the unweighed coal. There should preferably be no water supplied to the boiler, and if it is supplied, allowance should be made for same.

On reaching the terminal, the fire being in the same condition as at the start, the water level and water supply should be noted. The time the locomotive comes to rest should be the time of stop of test.

RECORDS.

The tests should be in charge of a competent person who is thoroughly familiar with road operations.

The number of observers required for a test depends upon the nature of the data to be obtained. When making an efficiency test at least six observers should be located on the locomotive, two for taking indicator diagrams and any other data that can be taken from the pilot box, two for cab data and two for coal and water records. It is frequently necessary to increase this force when taking special data.

In the dynamometer car at least three observers are required, one to record the time of each start and stop, passing each station and recording mile posts, point of curvature and tangent and any other important information; one to record all information on the diagram and keep track of indicator cards, and one to take car numbers and weights of trains; this

latter man can also act as a relief observer. When making test of Mallet type of locomotive, the locomotive force is increased to take indicator cards from the low-pressure cylinders.

The time to take records depends entirely upon what facilities are available for recording same. If a dynamometer car is available for the tests, records should only be taken when some change in the operation of the locomotive takes place, such as throttle lever, reverse lever and boiler pressure. If the dynamometer car is not available, all records should be taken preferably every five minutes.

Special reading of the meters and total number of sacks of coal fired should be taken at specified stopping and passing points.

Careful observations should be made throughout the run, of the time passing all important points, arriving and leaving each station, and the time that the throttle valve is opened or closed, not only at each stop, but when drifting.

ASH AND REFUSE.

In weighing and sampling the ash and refuse, the same preparation as described for laboratory tests should be followed as far as practicable.

SAMPLING COAL.

The coal should be sampled while it is being weighed off in 100-pound lots, and a small proportion taken at different times until about 300 pounds are obtained. This should be crushed and quartered and about one quart placed in an air-tight jar and sent to chemist for analysis. When this method of sampling is used, care should be taken that the coal does not take on additional moisture, due to leaky cistern or sprinkler. If there is any question as to the coal taking additional moisture after it is once weighed out, sample should be taken from each sack as it is emptied.

On all tests the total moisture should be used in all calculations.

CALORIFIC TEST OF COAL.

The same practice as used on laboratory tests for calorific tests of coal should be used on road tests.

DATA AND RESULTS.

The data and results should be reported in accordance with the form given for laboratory tests as far as practicable, and in addition a summarized form should be made giving the following information:

793. Date of test..
794. Average number cars (pushed or pulled)..........................
795. Gross tons, excluding locomotive................................
796. Number 100 gross ton-miles ....
797. Number 100 adj. ton-miles ....
798. Number of stops ....
799. Distance in miles..
800. Time on trip, hrs..

801. Time running — hours
802. Time throttle open — hours
803. Average speed, running throttle open — M. P. H.
380. Average boiler pressure lbs. per sq. in.
384. Average H. P. steam-chest pressure lbs. per sq. in.
385. Average L. P. steam-chest pressure lbs. per sq. in.
394. Draft, front of diaphragm — in. water
395. Draft, back of diaphragm — in. water
373. Temperature feed-water — Degrees Fahr.
368. Temperature air — Degrees Fahr.
409. Superheat in branch pipe — Degrees Fahr.
410. Superheat in receiver — Degrees Fahr.
411. Superheat in exhaust — Degrees Fahr.
804. Coal and how fired
418. Coal, total as fired, lbs.
626. Dry coal per hour fired, lbs.
627. Dry coal fired per hour per sq. ft. grate area, lbs.
805. Water, total out of tender, lbs.
806. Water, total evaporated, lbs.
638. Water loss — Calorimeter, safety valves, etc., lbs.
637. Water evaporated per pound fuel as fired, lbs.

EQUIVALENT EVAPORATION FROM AND AT 212° F.

645. Per hour, lbs.
648. Per hour per sq. ft. total fire heating surface
657. Per hour per pound coal as fired
660. Boiler H. P. (34.5 U of E)
666. Efficiency of boiler based on fuel — per cent.
639. Dry steam to engines — lbs. per hour
722. 723. I. H. P., high-pressure cylinders
724. 725. I. H. P., low-pressure cylinders
728. Total I. H. P.
734. Dry coal per I. H. P. hour, lbs.
736. Dry steam per I. H. P. hour, lbs.
487. Average drawbar pull, lbs.
743. Dynamometer or drawbar horse-power
744. Dry coal per D. H. P. hour, lbs.
745. Dry steam per D. H. P. hour, lbs.
807. Coal as fired per 100 gross ton-miles, lbs.
808. Coal as fired per 100 ton-miles, lbs.
809. Water per 100 ton-miles, lbs.
810. Coal as fired per car-mile, lbs.
811. Water per car-mile, lbs.

APPENDIX.

The method used for obtaining the data is in most cases self-evident, but that this may be clearly understood, the following are deemed sufficiently important to require special mention.

The Marks and Davis steam tables for saturated and superheated steam are used in all calculations pertaining to the properties of steam.

Item 318. $\frac{\text{Item 19}}{33{,}000}$

Item 319. Constant .000001983 (Item 68^2 — Item 144^2) × Item 77.

Item 320. Constant .000001983 (Item 68^2 — Item 135^2) × Item 77.

Item 321. Constant .000001983 (Item 69^2 — Item 145^2) × Item 78.

Item 322. Constant .000001983 (Item 69^2 — Item 136^2) × Item 78.

Item 323. Constant .000001983 (Item 70^2 — Item 146^2) × Item 79.

Item 324. Constant .000001983 (Item 70^2 — Item 137^2) × Item 79.

Item 325. Constant .000001983 (Item 71^2 — Item 147^2) × Item 80.

Item 326. Constant .000001983 (Item 71^2 — Item 138^2) × Item 80.

Item 332. Constant 229.16 × Item 319.

Item 333. Constant 229.16 × Item 320.

Item 334. Constant 229.16 × Item 321.

Item 335. Constant 229.16 × Item 322.

Item 336. Constant 229.16 × Item 323.

Item 337. Constant 229.16 × Item 324.

Item 338. Constant 229.16 × Item 325.

Item 339. Constant 229.16 × Item 326.

Item 352. $\frac{\text{Item 351}}{60 \times \text{Item 345}}$

Item 353. $\frac{\text{Item 352} \times \text{Item 19}}{88}$

Item 354. Item 352 × 2 × $\frac{\text{Item 77} + \text{Item 78} + \text{Item 79} + \text{Item 80}}{4}$

Item 407. $X = \frac{H + .48\,(t_s - t) - h}{r}$

t_s = temperature of steam in calorimeter in any case.
t = temperature due to saturated steam at calorimeter pressure.
h = heat of liquid due to absolute boiler pressure.
r = latent heat of dry steam due to the absolute boiler pressure.
H = total heat of dry steam due to absolute pressure in calorimeter.

Item 412. $X + (1 - X)\frac{h - h_1}{H - h_1}$

X = quality of steam.
h_1 = heat of liquid due to feed-water temperature.
H = total heat of dry steam due to absolute boiler pressure.

Item 419. Item 418 × $\frac{100 - \text{Item 440}}{100}$

Item 420. Item 418 $\times \frac{100 - \text{Item } 439 + \text{Item } 441)}{100}$

Item 421. Item 418 $\times \frac{\text{Item } 441}{100}$

Item 425. $\frac{\text{Item } 638}{\text{Item } 636}$

Item 458. $\frac{\text{Item } 443}{100 - \text{Item } 440} \times 100$

Item 459. $\frac{\text{Item } 443}{100 - \text{Item } 439 + \text{Item } 441} \times 100$

Item 626 $\frac{\text{Item } 419}{\text{Item } 345}$

Item 627. $\frac{\text{Item } 626}{\text{Item } 252}$

Item 633. $\frac{\text{Item } 481}{\text{Item } 345}$

Item 634. Item 633 $\times$ Item 412

Item 635. $\frac{\text{Item } 634}{\text{Item } 275}$

Item 636. $\frac{\text{Item } 634}{\text{Item } 626}$

Item 637. $\frac{\text{Item } 634}{\frac{\text{Item } 418}{\text{Item } 345}}$

Item 639. Item 633 — Item 638 $\times$ Item 412.

Item 640. Saturated steam $\frac{H - h_1}{970.4}$

H = total heat of steam in boiler.

Superheated steam $\frac{H + C_p\,(t_2 - t_1) - h_1}{970.4}$

H = total heat of steam at branch pipe (absolute pressure).

C = specific heat of superheated steam in the range of temperatures (t_1 to t_2).

t_1 = temperature, degrees F., of saturated steam at absolute branch pipe pressure.

t_2 = temperature of superheated steam as observed by thermometer in degrees F.

Item 645. Item 634 $\times$ Item 640.

Item 648. $\frac{\text{Item } 645}{\text{Item } 275}$

Item 656. $\frac{\text{Item } 645}{\text{Item } 252}$

Item 657. $\dfrac{\text{Item 645}}{\dfrac{\text{Item 418}}{\text{Item 345}}}$

Item 658. $\dfrac{\text{Item 645}}{\text{Item 626}}$

Item 659. $\dfrac{\text{Item 645}}{\dfrac{\text{Item 420}}{\text{Item 345}}}$

Item 660. $\dfrac{\text{Item 645}}{34.5}$

Item 666. $\dfrac{\text{Item 658} \times 970.4 \times 100}{\text{Item 458}}$

Item 667. $\dfrac{\text{Item 666}}{\text{Item 275}}$

Item 668. $\dfrac{\text{Item 666}}{\text{Item 252}}$

Item 697. $\dfrac{\text{Item 510} + \text{Item 86}}{\text{Item 495} + \text{Item 86}}$

Item 698. $\dfrac{\text{Item 511} + \text{Item 87}}{\text{Item 496} + \text{Item 87}}$

Item 699. $\dfrac{\text{Item 512} + \text{Item 88}}{\text{Item 497} + \text{Item 88}}$

Item 700. $\dfrac{\text{Item 513} + \text{Item 89}}{\text{Item 498} + \text{Item 89}}$

Item 707. Item 319 × Item 352 × Item 674.
Item 708. Item 320 × Item 352 × Item 675.
Item 709. Item 321 × Item 352 × Item 676.
Item 710. Item 322 × Item 352 × Item 677.
Item 712. Item 323 × Item 352 × Item 679.
Item 713. Item 324 × Item 352 × Item 680.
Item 714. Item 325 × Item 352 × Item 681.
Item 715. Item 326 × Item 352 × Item 682
Item 722. Item 707 + Item 708.
Item 723. Item 709 + Item 710.
Item 724. Item 712 + Item 713.
Item 725. Item 714 + Item 715.
Item 726. Item 722 + Item 724.
Item 727. Item 723 + Item 725.
Item 728. Item 726 + Item 727.

Item 734. $\dfrac{\text{Item 626}}{\text{Item 728}}$

Item 735. Item 734 × Item 458.

Item 736. $\dfrac{(\text{Item 633} - \text{Item 638}) \times \text{Item 412}}{\text{Item 728}}$

Item 743. Item 318 × Item 352 × Item 487.

Item 744. $\dfrac{\text{Item 626}}{\text{Item 743}}$

Item 745. $\dfrac{(\text{Item 633} - \text{Item 638}) \times \text{Item 412}}{\text{Item 743}}$

Item 746. Item 744 × Item 458.

Item 752. $\dfrac{\text{Item 626}}{\text{M}}$

M = million foot-pounds and is obtained by: $\dfrac{\text{Item 487} \times \text{Item 19} \times \text{Item 351}}{\text{Item 345}}$

Item 753. $\dfrac{(\text{Item 633} - \text{Item 638}) \times \text{Item 412}}{\text{M}}$

Item 754. Item 752 × Item 458.

Item 755. $\dfrac{\text{Item 728}}{\text{Item 275}}$

Item 756. $\dfrac{\text{Item 728}}{\text{Item 252}}$

$\dfrac{\text{Item 743}}{\text{Item 275}}$

$\dfrac{\text{Item 743}}{\text{Item 252}}$

Item 764. $\dfrac{33{,}000}{\text{Item 19}} \times \dfrac{\text{Item 728}}{\text{Item 352}}$

Item 770. Item 728 — Item 743.

Item 771. $\dfrac{\text{Item 770}}{\text{Item 352} \times (\text{Item 319} + \text{Item 320} + \text{Item 321} - \text{Item 322})}$

Item 772. $\dfrac{\text{Item 770} \times 33{,}000}{\text{Item 352} \times \text{Item 19}}$

Item 778. $\dfrac{\text{Item 743}}{\text{Item 728}} \times 100$

Item 779. $\dfrac{\text{Constant 254655.8}}{\text{Item 746}} \left(\dfrac{33{,}000 \times 60}{777.52} \times 100 = \text{Constant 254655.8}\right)$

Item 785. $\dfrac{\text{Item 63}}{\text{Maximum indicated horse-power}}$

Item 786. $\dfrac{\text{Item 275}}{\text{Maximum indicated horse-power}}$

METHOD TO DETERMINE DISCHARGE FROM LOCOMOTIVE SAFETY VALVES ON ROAD TESTS.

To determine the amount of steam discharged from the safety valves of a locomotive undergoing a road test necessitates the following preparation:

The outer side of one of the safety valves is drilled and tapped near the top of the muffler for the insertion of a plug (flush with the inside wall of the valve muffler), threaded at each end with a ⅜-inch pipe thread. The plug forms a conical convergent nozzle having a minimum orifice of $\frac{3}{32}$ inch in diameter. A ¼-inch wrought-iron pipe is run from the plug connection down to the rear of the locomotive cab roof, where a flexible connection, such as a rubber steam hose, is made of sufficient length to reach the bulkhead of the tender. From here a ¼-inch pipe is run down along the side of the tender to a point where it is directed into the water compartment and connected to a 1-inch coiled pipe, or condenser, extending down to the bottom of the tank and connecting with a small reservoir located on the outside of the tender frame. Steam, which is admitted to this line when the safety valves lift, is condensed in the coil and collected in the reservoir. A drain cock located at the bottom of the reservoir is used to draw off the condensed steam at the end of each test for the purpose of making the desired calibration.

The accuracy of the determination required previously demands a very careful calibration of the safety valve and the orifice, so as to ascertain the exact ratio of steam discharge through the orifice to the total amount of steam discharged through the safety valves. This ratio determined, and the amount of condensed steam passing through the orifice ascertained at the end of the test, the discharge at the safety valves may be calculated for the test period.

AIR BRAKE AND SIGNAL INSTRUCTIONS.

At the convention of 1892 a code of Air Brake and Signal Instructions was adopted as Recommendation of the Association. Some modifications were made in 1898, and the modified rules are shown on pages 205-228, report 1898. Revised, June, 1904. Revised in 1914. In 1914 the questions and answers regarding the use of the air-brake and trainman signals were eliminated.

The title of the revised instructions should be,

"AIR BRAKE AND TRAIN AIR SIGNAL INSTRUCTIONS."

"A"—GENERAL INSTRUCTIONS.

1. The following rules and instructions are issued for the government of all employees of this railroad whose duties bring them in contact with the maintenance and operation of the air brake and train air signal apparatus. They must be obeyed in all respects, as employees will be held strictly responsible for the observance of same.

Every employee whose duties are connected in any way with the maintenance and operation of the air brake will be examined from time to time as to his qualifications for such duties by the Inspector of Air Brakes or other person appointed by the proper authority, and a record will be kept of such examination.

Any employee whose work indicates an apparent lack of the requisite brake knowledge will be required to pass an examination at any time following such indications.

"B"— INSTRUCTIONS TO ENGINEMEN.

2. Enginemen when taking charge of locomotives must see that the air brake and train air signal apparatus on engine and tender is in good working order and that the air compressor and lubricator work properly; that the devices used for regulating all pressures are adjusted at the authorized amount; that brake valves work properly in all positions; and that, when brakes are fully applied, with cam type of driver brake, the pistons do not travel less than 2 in., nor more than 3½ in., and with other forms of driver brakes from 4 to 6 in.; that the engine truck and trailer brake piston travel be not less than 4, nor more than 6 in.; that the tender brake piston does not travel less than 6 nor more than 8 in.

Enginemen must report to roundhouse foremen, in writing, at the end of the run, any defects in the air brake or train air signal apparatus.

3. Making Up Trains. Testing Brakes at Terminal Points and Before Starting Down Such Grades as May Be Designated by Special Instructions.— The brake pipe on the engine and under the tender must always be blown out and maximum pressure obtained in main reservoir before coupling engine to train.

After the train has been coupled, stretched and fully charged, the engineman shall, at the request of the inspector or trainmen, apply the brakes with full service application and hold them so applied until all brakes operated from the engine have been inspected and the signal given to release. The engineman must then release the brakes and he must not leave the station until it has been ascertained that all brakes are released and he has been so informed by the inspector, or the trainmen, of the number of brakes in service and of their condition. If any defect is discovered during this test same must be corrected and brakes again tested, and the operation repeated until the brakes are known to be in good condition.

In testing passenger train brakes, signal for releasing must be given from the air signal discharge valve on rear car.

Following the separation of couplings for local switching, or when engine is parted from train, or train has been parted for any purpose, the above test need not be complied with further than to ascertain, by test, that the rear brakes are responsive to brake valve on engine and that all brakes have properly released. However, when cars are added to train, the brakes on such cars must be inspected as in terminal test. When a back-up hose is to be used to control the train, the brakes must be applied for test with the back-up hose, and released from the brake valve on the engine.

4. Service Application — Passenger Trains.— In making service stops from high speed, two applications should be used. The first application should be derived from two or more brake-pipe reductions, and when

the speed has reduced to about fifteen miles per hour, release all brakes, and complete the stop with a moderate service application.

In making service stops with trains of less than seven cars, the brakes should be released about the time the drivers make the last revolution, except on heavy grades. Even on moderate grades and when stopping at water stations, coaling chutes, short platforms, etc., this should be done, and after releasing re-apply the brakes, either automatic or independent, as required, to prevent the train from starting. To avoid shocks and train parting the brakes must not be released on trains of seven or more cars while moving at a speed of less than ten miles per hour.

If *undesired quick action* has taken place during a service application on trains of more than five cars, the brakes must not be released until the train comes to a stop.

5. Service Application — Freight Trains.— In applying the brakes to steady the train on descending grades, or for reducing speed for any purpose, an initial brake-pipe reduction of not less than 7 lb. must be made. Releasing brakes at low speeds must not be attempted unless local conditions are favorable for same.

Ample time should always be allowed for making the stop, first permitting the slack of train to become adjusted before commencing to use the brake. After this the first brake-pipe reduction should be made and it should be sufficiently heavy to make the stop, being not less than 7 or more than 12 lb., according to the length of the train. Then when not more than a car length (40 ft.) short of the completion of the stop, a second reduction sufficiently heavy should be made to cause the brake valve to be blowing when stop is completed. After a reduction to apply brakes, no attempt must be made to release, until air ceases to discharge from the brake-valve pipe exhaust.

When backing freight trains and it is desired to stop, apply the brake in service, and when conditions permit, keep the driver brake from applying and the throttle open until stop is complete, the idea of keeping the engine brake released and using steam while train brake is applying being to keep the slack of train bunched and thus prevent train parting.

6. Emergency Applications.— The emergency application of the brakes must be used only in actual emergencies. Under such conditions the brake valve must be left in emergency position until train has come to a stop.

ENGINEMEN'S STRAIGHT AIR OR INDEPENDENT BRAKE VALVES.

(A) Always keep both brakes cut in and ready for operation, unless failure of some part requires cutting out.

(B) Always carry an excess pressure of 20 lb., or more, in the main reservoir, as this is necessary to insure a uniformly satisfactory operation.

(C) The straight air or the independent brake valve should not be used for bunching the slack of the train previous to an automatic application; neither should it be used alone for making ordinary stops with a train.

(D) The reducing valves for the straight air and the independent brake and the safety valves for the locomotive brakes should be kept adjusted at the authorized pressures.

When a full application of the straight air or of the independent brake causes any of the safety valves to operate, it indicates that same is out of order, or too high adjustment of the reducing valve or too low adjustment of the safety valve, or leakage of same. Have them tested and adjusted.

7. Brakes Applied From An Unknown Cause.— If it is found that the train is dragging as though the brakes were applied, without rapid falling of the brake-pipe pressure pointer, the engineman must make an effort to release the brakes, which may be done as follows: First, if brake-pipe pressure is less than the authorized amount and the required excess pressure is carried in the main reservoir, move the handle of the brake valve to release position for an instant and then return it to running position; second, should the brake pipe be fully charged with pressure, apply the brakes with a heavy service reduction, and release them in the usual way. In case the brakes can not be released in this manner, the train must be stopped and the trainmen notified.

If, however, the brakes go on suddenly with a rapid fall of brake-pipe pressure, it is evidence that (A) a conductor's valve has been opened, (B) a hose has burst or other serious leak has occurred, or (C) the train has parted. In such an event the engine throttle should be closed and the brake-valve handle immediately placed in lap or in emergency position, to prevent the escape of air from the main reservoir, and left there until the train has stopped and the signal to release has been given.

8. Braking By Hand.— Hand brakes must not be used, except in emergency.

9. Cutting Out Brakes.— *The engine and tender brakes must always be used automatically at every application of the train brake,* unless defective, except upon such grades as shall be designated by special instructions.

When necessary to cut out either the engine or the tender brake, it shall be done by closing the cut-out cock, located between the brake pipe and triple valve, and opening the drain cock in the auxiliary reservoir, on locomotives so equipped. On locomotives having the ET or the LT equipment close the cut-out cock in the pipe leading to the respective brake cylinder.

10. Double Headers.— When two or more engines are coupled in the same train, the brakes must be connected through to and operated from the leading engine. Engineman of each engine, except the leading one, must close the double-heading cock below the automatic brake valve and carry the handle of brake valve in running position. He will run the compressor for the purpose of maintaining pressure on his engine, and of enabling him to assume charge of the train brakes should occasion require.

11. Dead Engine Feature.— Its purpose is to supply to the main

reservoir for operating brakes and other devices on engines where pump has failed, or on dead engines en route. In both cases the cut-off cock in this device must be kept open and handle of both brake valves on such engines left in running position, and the double heading cock below automatic brake valve kept closed.

The dead engine cut-out cock must be kept closed on all engines where pumps are running.

"C"—INSTRUCTIONS TO TRAINMEN.

12. MAKING UP TRAINS AND TESTING AIR BRAKES.—After the locomotive has been coupled to the train, or after two sections have been coupled together, the brake and signal couplings must be united, the cocks in the brake and signal pipes must all be open, except those at the rear end of the last car, which must be closed, and the hose hung up in the dummy couplings.

After the train has been coupled, stretched, and fully charged, the engineman must be requested to apply the brakes. When he has done so, the brakes of each car must be examined to see if they are properly applied. When it has been ascertained that each brake has been so applied, the engineman should be signaled to release.

In testing passenger-train brakes the train air signal whistle code for releasing must be used, and the signals to release must be given from the air signal apparatus on the rear car. The brakes of each car must then be examined to see that each is released, and the engineman informed as to the number of brakes in service and of their condition.

If any defect is discovered it must be remedied and the brakes tested again — the operation being repeated until it is ascertained that everything is right. The conductor and engineman must then be notified that the brakes are all right. Following the separation of couplings for local switching or when engine or train has been parted for any purpose, the above test need not be complied with other than to ascertain, by test, that the rear brakes are responsive to brake valve on engine, and that all brakes have properly released.

No passenger train must be started out from its terminal with the brakes upon any car cut out or in a defective condition. The air brakes must be relied upon to control all trains.

13. DETACHING LOCOMOTIVE OR CARS.—First close the cocks in the brake and signal pipes at the point of separation, and then part the couplings by hand.

COUPLINGS FROZEN.—If the couplings are found to be frozen together or covered with ice, the ice must first be removed and then the couplings thawed to prevent injury to the gaskets.

14. BRAKE STICKING.—If brakes are found sticking, the signal for "brakes sticking" must be given, in which case, if the brakes can not be released from the engine, or if the brakes are applied to detached cars, the release may be effected by opening the release valve in the auxiliary reser-

voir until the air begins to release through the triple valve, when the valve must be closed.

15. Train Breaking In Two or More Parts.— First close the cock in the brake pipe at the rear of the first section, and then signal the engineman to release the brakes. Having coupled the second section, observe the rules for making up trains — first being sure that the cock in the brake pipe at the rear of second section has been closed, if the train has broken in more than two sections. When the engineman has released the brakes on the second section, the same method must be employed with reference to the third section, and so on. When the train has been once more entirely united the brakes must be inspected on each car to see that all are released before proceeding.

16. Cutting Out the Brakes On a Car.— When necessary to cut out the brake upon any car, close the cut-out cock in the cross-over pipe near the triple valve, and open the drain cock in the auxiliary reservoir, leaving it open on passenger cars.

On freight cars the release valve must be held open until all of the air has escaped from the reservoir, when an air-brake defect card must be applied. The conductor must notify the engineman of brake cut-out.

17. Conductor's Valve.— Should it become necessary to apply the brakes from the train, it may be done by opening the conductor's valve in any car so equipped. *The valve must be held open until the train comes to a stop, and then must be closed.*

This method of stopping the train must not be used except in case of emergency.

18. Burst Hose.— In the event of the bursting of a brake hose, it must be replaced and the brakes tested before proceeding, so as to ascertain that the rear brakes are responsive to the brake valve on engine. At least one extra air-brake hose complete should be carried by all crews, and in addition one extra signal hose complete carried by passenger crews.

19. Brakes Not In Use.— When the air brakes are not in use, the hose should be kept coupled between the cars or hung to the dummy couplings when cars are so equipped.

20. Pressure Retaining Valve.— When this valve is to be used, the trainmen must, at the top of the grade, at the point authorized, test the brakes upon the whole train, and must then pass over the train and turn the handles of the pressure-retaining valves upon all or upon a part of the cars, as may be directed, to proper position for retaining pressure. At the foot of the grade, the handles must be turned downward (lengthwise with pipe) again. Special instructions will be issued as to the grades upon which these valves are to be used.

21. Train Air Signal.— In making up trains, all couplings and car discharge valves on the cars must be examined to see if they are tight. Should the car discharge valve upon any car be found defective, it may be cut out by closing the cock in the branch pipe leading to it. The conductor must be notified when the signal has been cut out upon any car, and he must report the same for repairs.

In using the signal, pull down upon the cord during one full second for each intended blast of the signal whistle, and allow three seconds to elapse between the pulls.

22. Reporting Defects to Inspectors.— Any defect in either the air brake or the train air signal apparatus must be reported to the inspector on arrival at terminal; or, if the defect be a serious one in passenger service, it must be reported to the nearest inspector, and such defect must be remedied before the car proceeds.

"D" INSTRUCTIONS TO ENGINE-HOUSE FOREMEN.

23. General.— It is the duty of the engine-house foreman to know that the air brake and train air signal equipment is properly inspected upon each locomotive after each run, and that necessary repairs are made before leaving the engine house. Air gauges must be tested at least once every thirty days, and date of testing shown.

24. Air Compressors.— The air compressors must be tested for efficiency by orifice test, and their condition determined.

Compressors must be started slowly with drain cocks open, these cocks to be left open until compressor is free from all condensation. They must also be left open while compressor is not working.

25. Compressor Governor.— The compressor governor should cut off the steam supply when the air pressure for which it is adjusted has been obtained, and promptly admit steam to the compressor when air pressure falls slightly below the authorized amount.

26. Brake Valves.— These valves must be kept clean and be known to be in working order in all their positions before the engine leaves the engine house.

27. Adjustment of Brakes.— Engine brake piston travel should not be less than 4 nor more than 6 in.; for tender brake not less than 6 nor more than 8 in. When cam driver brake is in use piston travel should be not less than 2 in. nor more than 3½ in., and care must be taken to adjust both cams alike, so that the point of contact of the cams will be in line with the piston rod; the brake shoes should be correctly adjusted at equal distances from the wheel at the top and bottom of the shoe and in line with the tires.

28. Brake Cylinders and Triple Valves.— Engine and tender brake cylinders, plain triple valves and high-speed reducing valves should be cleaned, lubricated and tested, at least once in six months; when locomotive is equipped with distributing valve or control valve, or the tender has a quick action triple valve, these parts should be cleaned and tested at least once in three months. Time and place of cleaning to be stenciled according to standard drawings.

29. Draining.— The main reservoir, and also the drain cup and dirt collector in the brake pipe under the tender, must be drained of any accumulation after each trip. The auxiliary reservoirs and triple valves must also be drained frequently, and daily in cold weather, and the brake pipe under the engine and tender blown out.

30. Train Air Signal.— The train air signal apparatus must be examined and tested, both at front of engine and rear of tender, before every trip by means of a suitable appliance to which is attached an air gauge for testing the pressure carried. It must be known that the whistle responds properly; also that the pressure-reducing valve maintains the authorized pressure.

"E"— INSTRUCTIONS TO INSPECTORS.

31. General.— It is the duty of all inspectors to see that the couplings, the pipe joints, the triple valves, the high-speed reducing valves, the conductor's valves, the air-signal valves, and all other parts of the brake and signal apparatus are in good order, of standard size for the car, and free from leaks. For this reason they must be tested under the full air pressure as used in service. No passenger train must be allowed to leave a terminal station with the brake upon any car cut out, or in a defective condition.

If a defect is discovered in the brake apparatus of a freight car, which can not be held long enough to give time to correct such defect, the brake must be cut out and the car properly carded, to call the attention of the next inspector to the repairs required.

Special rules will specify the smallest proportion of the total number of freight cars, with the air brakes in good condition, which may be used in operating the train as an air-brake train.

32. Making Up Trains and Testing Brakes.— In making up trains, the couplings must be united and the cocks at the ends of the cars all opened, except at the rear end of the last car, where the cocks must be closed; the inspector must know that the air is passing through the pipes to the rear end, and the hose couplings at the rear are properly attached to the dummy couplings on cars so equipped.

After the train is stretched and fully charged, the engineman must be requested to apply the brakes. After the brakes are applied they must be examined upon each car to see that they have the proper piston travel. This having been ascertained, the inspector must signal the engineman to release the brakes.

In testing passenger-train brakes, the signal to release must be given from the discharge valve on the rear car. He must then again examine the brakes upon each car to note that all have released. If any defect is discovered, it must be corrected and the testing of the brakes repeated, until they are found to work properly. The inspector must then inform both the engineman and conductor of the number of cars with brakes in good order.

The examination must be repeated if any change is made in the make-up of the train before starting.

33. Cleaning Cylinders, Triple Valves and Slack Adjusters.— The brake cylinders and triple valves on freight equipment cars must be cleaned, lubricated and tested, at least once in twelve months, and the

method of marking brake apparatus which has been cleaned, lubricated and tested, should be as shown in Rule No. 60, of M. C. B. Rules of Interchange.

On passenger cars, the cylinders, triple valves and slack adjusters must be cleaned and lubricated at least once in six months, and in case cars are equipped with high-speed brakes, the triple, high-speed valves and control valves must be cleaned at least once every three months, and date and place of last cleaning stenciled on these parts with white paint.

The triple valves and auxiliary reservoirs must be frequently drained, especially in cold weather, by removing the plug in the bottom of the triple valve and opening the drain cock in the bottom of reservoir.

34. Adjustment of Brakes.— The slack of the brake shoes must be taken up by means of the truck dead levers on cars having four-wheeled truck and at the turnbuckle nearest the center of the car on cars having six-wheeled trucks. In taking up such slack it must first be ascertained that the hand brakes are released, and the slack is all taken out of the upper connections, so that the truck levers do not go within one inch of the truck timber or other stop, when the piston of the brake cylinder is fully back at the release position.

When under a full application the brake piston travel is found to exceed 9 in. upon passenger or freight cars, the brake shoe slack must be taken up and adjustment so made that the piston shall travel not less than 6 in. In taking up the brake shoe slack it must never be taken up by means of the hand brakes. Where automatic slack adjusters are applied to any car, such adjuster must be fully released before the slack is taken up elsewhere, and where cars are equipped with double apparatus it must be seen that both slack adjusters are evenly adjusted.

35. Braking Force.— Where the cylinder lever has more than one hole at the outer end and different holes are for use upon cars of different weights, it must be carefully ascertained that the rods are connected to the proper holes, so that the correct braking force shall be exerted upon each car.

36. Repair Parts.— Inspectors must keep constantly on hand for repairs supply of all parts of the brake and signal equipment that are likely to get out of order.

37. Hanging Up Hose.— Inspectors must see that, when cars are being switched or while standing in the yard, the hose is coupled between the cars or properly secured in the dummy couplings, where cars are so equipped.

38. Responsibility of Inspectors.— Inspectors will be held strictly responsible for the good condition of all the brake and signal apparatus upon cars placed in trains at their stations; they will also make examinations of the brakes, and such repairs as may be required.

BASIC PRINCIPLES RELATING TO THE HANDLING OF APPRENTICES.

At the convention of 1898 a code of apprenticeship rules was adopted as the Recommendation of the Association. In 1908 a series of basic principles relating to the handling of apprentices was adopted in lieu of the former code.

1. To develop from the ranks in the shortest possible time carefully selected young men for the purpose of supplying leading workmen for future needs, with the expectation that those capable of advancement will reveal their ability and take the places in the organization for which they are qualified.

2. A competent person must be given the responsibility of the apprenticeship scheme. He must be given adequate authority, and he must have sufficient attention from the head of the department. He should conduct thorough shop training of the apprentices, and in close connection therewith should develop a scheme of mental training, having necessary assistance in both. The mental training should be compulsory, and conducted during working hours at the expense of the company.

3. Apprentices should be accepted after careful examination by the apprentice instructor.

4. There should be a probationary period before apprentices are finally accepted; this period to apply to the apprentice term if the candidate is accepted. The scheme should provide for those candidates for apprenticeship who may be better prepared as to education and experience than is expected of the usual candidate.

5. Suitable records should be kept of the work and standing of apprentices.

6. Certificates or diplomas should be awarded to those successfully completing the apprentice course. The entire scheme should be planned and administered to give these diplomas the highest possible value.

7. Rewards in the form of additional education, both manual and mental, should be given apprentices of the highest standing.

8. It is of the greatest importance that those in charge of apprentices should be most carefully selected. They have the responsibility of preparing the men on whom the roads are to rely in the future. They must be men possessing the necessary ability, coupled with appreciation of their responsibility.

9. Interest in the scheme must begin at the top, and it must be enthusiastically supported by the management.

10. Apprenticeship should be considered as a recruiting system, and greatest care should be taken to retain graduated apprentices in the service of the company.

OPERATION OF BRAKES ON ENGINES AND TENDERS HANDLED DEAD IN TRAINS AND OFFERED IN INTERCHANGE. RECOMMENDED PRACTICE.

In 1915 the following rules for the operation of brakes on engines and tenders handled dead in trains and offered in interchange were adopted as Recommended Practice.

1. All engines equipped with side rods must have them applied, when handled dead in trains, suitable washers, of wooden blocks clamped together with bolts, being used where necessary on main rod bearings to keep the side rods in place.

2. All engines and tenders hauled dead in trains must have the air brakes cut in and operative on drivers, trailers and on tender trucks.

3. Engines and tenders equipped with the Westinghouse ET, or New York LT brake, must have the safety valve on the distributing valve, or control valve, adjusted to not less than 25 lb. or more than 30 lb.

4. Engines and tenders equipped with the automatic and straight air combined must have the safety valve in brake cylinder pipe adjusted to not less than 25 lb. or more than 30 lb.

5. Engines equipped with Westinghouse ET, or New York LT brakes, or with straight air, must have positive stops applied to handles of automatic and independent valves to secure these handles in running position.

6. Engines and tenders equipped with high speed brake without the straight air, must have the high speed reducing valve set to reduce the brake cylinder pressure to not less than 25 lb. or more than 30 lb., or must have a safety valve applied to the brake cylinders or the brake cylinder pipe set to not less than 25 lb. or more than 30 lb.

7. Engines and tenders equipped with only the automatic brake must have a safety valve applied to the brake cylinders or the brake cylinder pipe set to not less than 25 lb. or more than 30 lb.

8. Engines fitted with power brakes other than air must be equipped with an air train line and connections.

9. Delivering line will be held responsible for flat spots on driving tires, trailer tires and tender truck wheels.

10. Owners shall be responsible for any special application of safety valves as required in Sections Nos. 3 to 8, inclusive.

PHOTOMETERING OF LOCOMOTIVE HEADLIGHTS RECOMMENDED PRACTICE.

In 1915 the following method of photometering headlights were adopted as Recommended Practice:

Method of Photometering.

In last year's report your committee described in detail the apparatus and method used in the Columbus tests for photometering headlights, and on page 780 of the report they recommend that apparatus, conforming in all details to that used at Columbus, shall be used in future investigations of this nature. This apparatus is somewhat cumbersome, however, and

requires that a permanent location and considerable floor space be given to it. As shop space is usually very valuable, your committee is of the opinion that a device of this kind will not find extensive use. A photometer table, constructed entirely of metal, has been developed along somewhat different lines, which, it is thought, will be more readily adaptable to railway service. This table is so designed that it may be readily handled or moved about, and may be set up in any location where sufficient floor space is available.

This table is shown in Exhibit "A." It consists of a platform (a) on which the headlight is mounted. This platform (a) is adjusted vertically by a screw (b) until the axis of the headlight corresponds with the point (c). The platform (a) and its adjusting-screw (b) are supported by a cradle (d), swinging in a vertical plane above a horizontal axis through the point (c), the whole being supported by a "U" frame (e) of steel tubing. The "U" frame (e) is in turn supported by and rotated horizontally on a metal base (f), provided with adjusting-screws for leveling. The platform (a) may be rotated about three degrees in either direction for finding the optical axis of the headlight. The scale (g) indicates the vertical angle and the scale (h) the horizontal angle through which the headlight is rotated. Both of these scales should be provided with verniers for accurate reading.

Space not less than 9 ft. wide by 9 ft. high and 30 ft. or more in length, depending upon the type of headlight to be photometered, must be provided and enclosed on all sides with light, tight material. Heavy canvas or oilcloth may be used for this purpose, and all interior surfaces must be painted dull black to avoid reflection. A candle-foot photometer is mounted at one end and the headlight table at the other end of the room. Between these a series of at least three canvas screens, painted dull black on both sides, should be attached to the ceiling, floors and walls. A hole approximately 1 ft. square should be cut in each screen on the axis of the headlight. The candle-foot photometer is mounted outside the photometer room, the milk-glass tube projecting through the end wall on the horizontal axis of the headlight.

The headlight should be set up at the following distances from the milk glass of the candle-foot photometer, depending upon the apparent beam candle-power of the headlight, as follows:

Apparent beam candle-power of headlight.	Distance of headlight from milk glass of candle-foot photometer.
1000 or less	15 ft.
1000 to 10,000	25 ft.
Above 10,000	50 ft.

The method of measuring this distance for parabolic reflectors, semaphore type of lenses, or inverted semaphore type of lenses is shown on Exhibit "B." Readings are taken by rotating the headlight, both vertically and horizontally, to throw on the milk glass of the candle-foot photometer those rays of light corresponding to the reading stations recommended in last year's report.

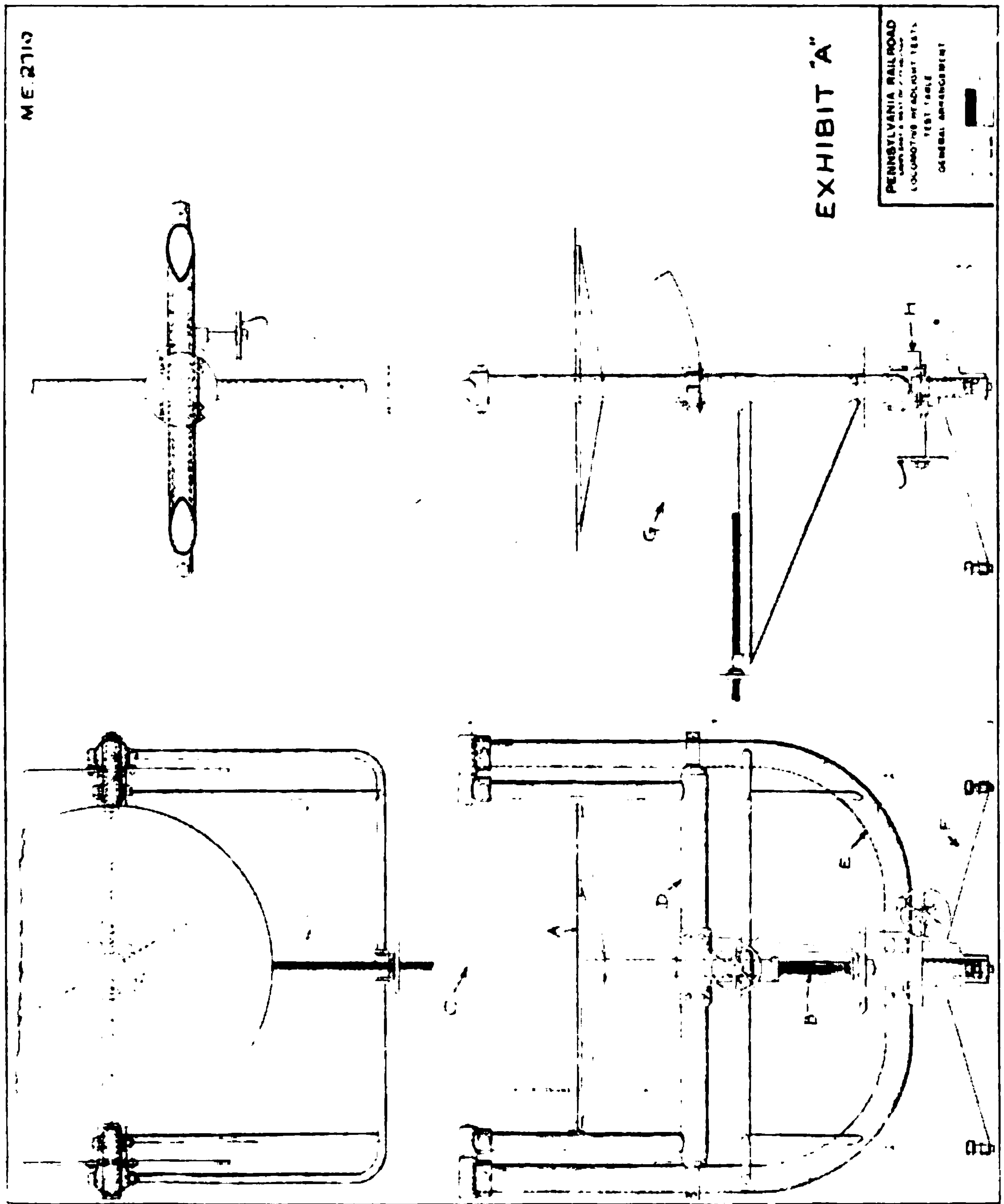
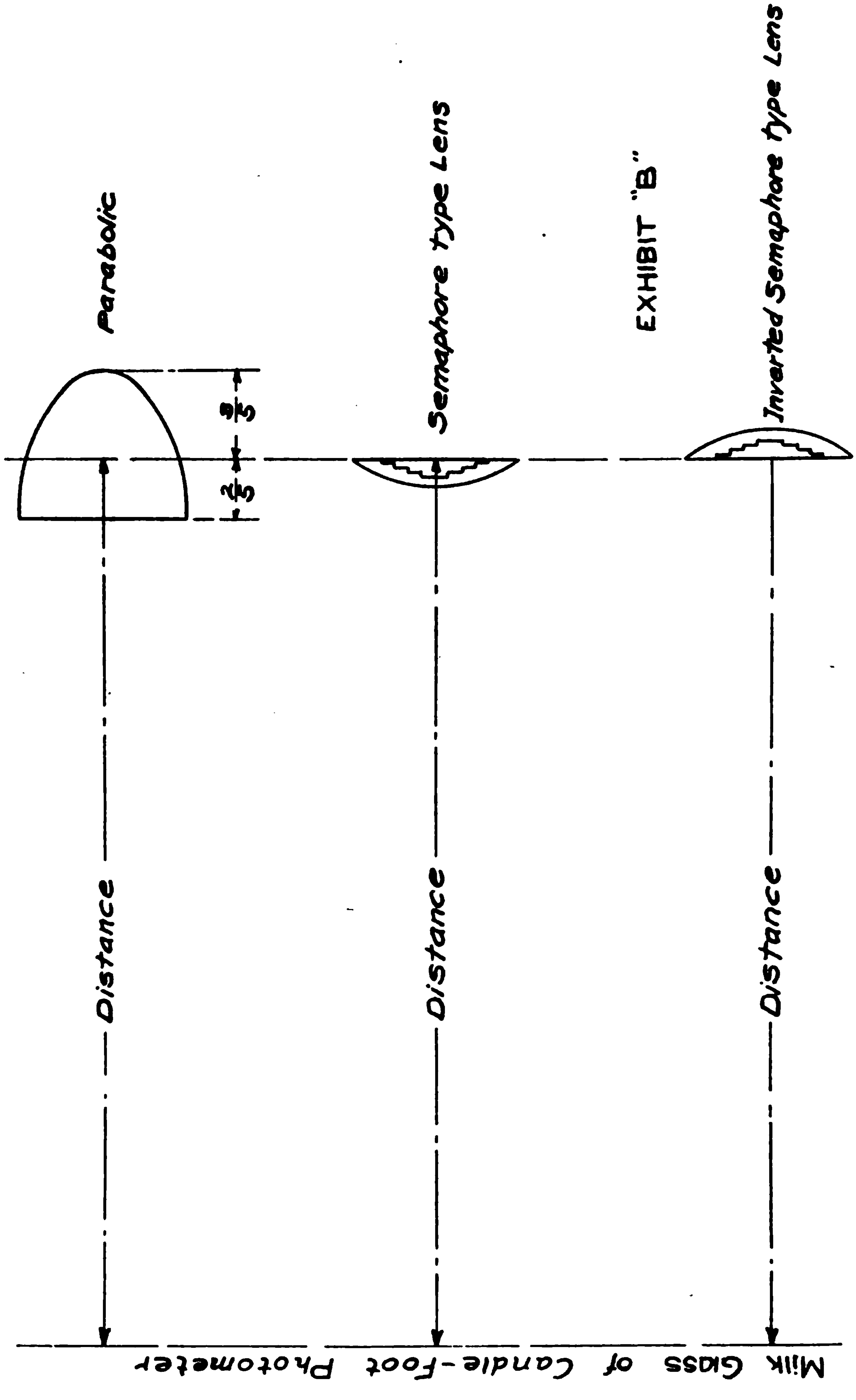


EXHIBIT "A"
PENNSYLVANIA RAILROAD
LOCOMOTIVE HEADLIGHT TESTS
TEST TABLE
GENERAL ARRANGEMENT
A
B
C
D
E
F
G
H


Parabolic
Semaphore type Lens
EXHIBIT "B"
Inverted Semaphore type Lens
Distance
Distance
Distance
Milk Glass of Candle-Foot Photometer

In 1915 the following rules for determining stresses in locomotive boilers were adopted as Recommended Practice.

1. LONGITUDINAL BARREL SEAMS AND PATCHES.

(a) In figuring net section of plate, use the actual diameter of rivet hole.

(b) In figuring rivet shear, use the actual diameter of the rivet after driven.

(c) In figuring stress in plate and shear in rivet, in case the barrel is not cylindrical where it joins the fire-box wrapper sheet, use the maximum diameter. Surfaces subject to bending action under pressure must be adequately braced to prevent bending stresses.

(d) When boiler shells are cut to apply steam domes or manholes, the amount of metal in flange and liner shall be equal in strength to the metal removed. When separate flange is used at base of dome, the entire net area of same shall be assumed as reinforcement. Where dome sheet is flanged direct to shell of boilers, a vertical distance of 2 in. from base of flange shall be assumed as reinforcement, using net area after rivet holes are deducted and using 28,500 lb. tens. str. per sq. in. as the ultimate strength, if dome sheet is welded vertically.

(e) Investigation of the strength of seams shall be along the lines of established engineering practices and formula for efficiency and strength and in accordance with paragraphs (a) and (b). Investigation of the strength of the seams by the usual engineering formula is a definite and determinable problem and there shall be no variations introduced in the usually accepted methods.

2. LONGITUDINAL GUSSET BRACES AND FLAT SURFACES.

(a) In figuring stress in diagonal braces, allowance for the angularity of the brace shall be made.

(b) The sectional area of the brace and the strength of the attachment of the brace to the shell shall both be investigated and the lowest net strength shall be used.

(c) In determining the strength of gusset braces for supporting back head and tube sheets, use 100 per cent of rivet-bearing area, 80 per cent of rivet shear area and 90 per cent of gusset plate area, measured at right angles to the longest edge of gusset sheet, and of the three, select the minimum value.

(d) The calculation of stress in gusset braces shall cover both the section of the plate and strength of fasteners, and the lowest net strength shall be used.

(e) In figuring flat stayed surfaces, such as back heads, the boundary of the unsupported flat surface shall be located at a distance equal to outside radius of flange measured from inside of shell.

(f) No supporting value shall be assigned to the stiffness of flat plates on flat surfaces, as it is too small to be of material value.

(g) Reinforcing plates, such as back head liners, shall not be figured as having any staying or supporting value, but shall merely be considered as mechanical reinforcements for various attachments, such as longitudinal stays, staybolts, etc.

(h) The distance beyond the outer row of flues on tube sheets, assumed to be self-supporting, shall be 2 in.

(i) In calculating the area to be stayed on front tube sheet, the area of the dry pipe hole shall be deducted.

(k) Tee irons or other members, when used subject to bending, shall be calculated without addition for strength of plate, and the stress in such beam and its abutments must not exceed 12,500 per sq. in. The spacing of the rivets over the supported surface shall be in conformity with that specified for staybolts. No allowance for value of such beams shall be made in calculating the total area of longitudinal braces that may be attached thereto.

(l) Where there are a number of diagonal stays supporting a flat surfact, such as back head or front tube sheet, the proportion of area allotted to each brace shall be as follows:

Divide the entire net area to be stayed by the entire net area of braces. If it is felt that any individual brace is so segregated as to receive more than its fair proportion of the load, it shall be investigated separately as to the area which it supports.

(m) Patches when applied to the barrel of a boiler shall be designed with longitudinal and circumferential seams at least equal in strength to the main longitudinal and circumferential barrel seams. Patches may be applied to flat stayed surfaces with properly designed single-riveted seams without impairing the strength of the sheet.

3. STAYBOLTS — RADIAL STAYS AND CROWN BAR BOLTS.

(a) In figuring the net area of staybolts to obtain the stress, the area of the tell-tale hole shall be deducted.

(b) When figuring area at root of thread, the area must depend upon the type of thread used, namely, United States, V or Whitworth threads, as the case may be.

(c) In determining the area for figuring stress on staybolts, the area of one staybolt shall be deducted from the rectangular area included between any four staybolts.

(d) In boilers with crown bars supported on fire-box side sheets and sling stays, the sling stays shall be considered as carrying the entire load.

In 1915 the following designs for all classes of tinware in general use by the mechanical departments were adopted as Recommended Practice. A description and an illustration of these articles follow:

Fig. 1 shows an engineer's torch. The special feature of this torch is a cap which screws over the top and prevents oil wasting out into the seat box when the torch is not in use. While this torch is not tinware, it is used as a substitute for tinware.

Fig. 2 shows a very satisfactory form of torch, used on some roads for enginemen and shopmen.

Fig. 3 is a squirt oil can made of tin.

Fig. 4 is a pressed-steel squirt oil can, which can be purchased in the market, and is merely shown as an alternative where such a can is desired.

Fig. 5 shows two forms of long-spout engine oil can in quite general use. It is claimed that the amount of oil saved by the use of these cans will pay for the cost of construction.

Fig. 6 is a one-pint signal oil can. This is furnished on the engine, principally in winter weather, to carry a small amount of oil for emergency use. It is made small and compact to withstand rough usage and to save material. This can may also be used as a lamp filler for train service, station service, or where such a filler is required.

Fig. 7 is a three-pint valve-oil can with an internal strainer made of perforated tin. The opening in the top is made small to require the heating of the valve oil before putting it in the can, so that it will readily strain through the perforations.

Fig. 8 shows a five-pint valve-oil can, designed along the same lines, excepting the elliptical formation. The purpose of this form of construction is to give a large-capacity can, placing the handle on the side, enabling same to be used in a minimum of space between the lubricator and the roof of the cab.

Fig. 9, two-quart oil can, with double-folded seams.

Fig. 10, one-gallon can, of similar design. Both of these cans were made the same diameter, which will permit using the same dies in construction.

Fig. 11 is a two-gallon oil can, similar in construction to Figs. 9 and 10.

Fig. 12, three-gallon oil can, made of galvanized iron, has the bonnet so constructed as to permit of a free outlet for the oil. The iron band riveted to the flanged edge of the bottom protects the can from rough usage.

Fig. 13, five-gallon, and Fig. 14, ten-gallon, are constructed along similar lines.

Fig. 15 is a cheap form of card case that is fastened to the inside of the cab to hold the Federal Boiler Inspection card.

Fig. 16 is a form of card case, also nailed to the side of the cab, to receive the individual boiler-washout card. The dimensions of these may be varied to suit the cards used on the individual roads.

Fig. 17 is a two-gallon tank bucket.

Figs. 18 and 19 show two designs of sand buckets, where such an article is necessary.

Fig. 20 is a form of sponge bucket for engine-house use. This bucket has a capacity of four gallons or 50 lb. of saturated sponging. It is made elliptical for convenience in carrying, and will hold enough sponging to pack one side of a Pacific type engine, trailer and engine trucks.

Fig. 21 is a one-pound emery can, with a small opening which directs the emery onto the spot where it is required.

Fig. 22, a universal form of marking pot.

Fig. 23, a convenient and sanitary form of dust-pan.

Figs. 24, 25 and 26, three sizes of funnels, which should take care of all requirements in the mechanical department.

Figs. 27, 28, 29 and 30, one-pint, one-quart, two-quart and one-gallon measures. These measures are made with parallel sides to economize in labor and material.

Fig. 31, two-gallon oil can, with a removable brass tip so that the size of hole may be varied as required. The use of this oil can is not recommended in engine houses.

Figs. 32 and 33 show two forms of sprinkling cans, which may also be used for cooling cans, if desired, by removing the rose.

Fig. 34, a plain and economical form of coal hod.

Fig. 35, two-gallon pail.

Fig. 36, four-gallon pail.

Fig. 37, fiber fire bucket.

Fig. 38, a form of soil can that is used where Pullman car and private cars are required to stand in the terminal while occupied.

Figs. 39 and 40, garbage and refuse cans, shown with and without cover.

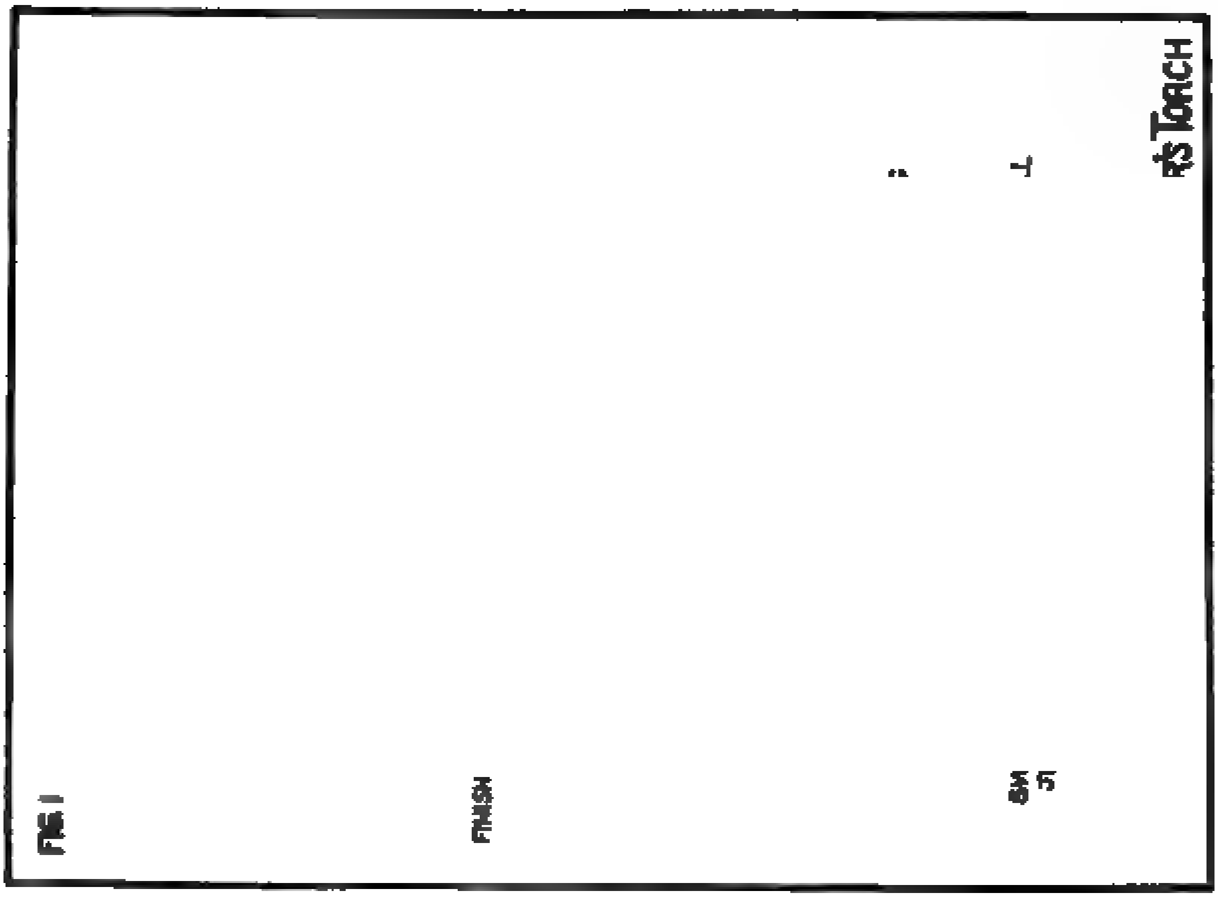


FIG. 1
FINISH

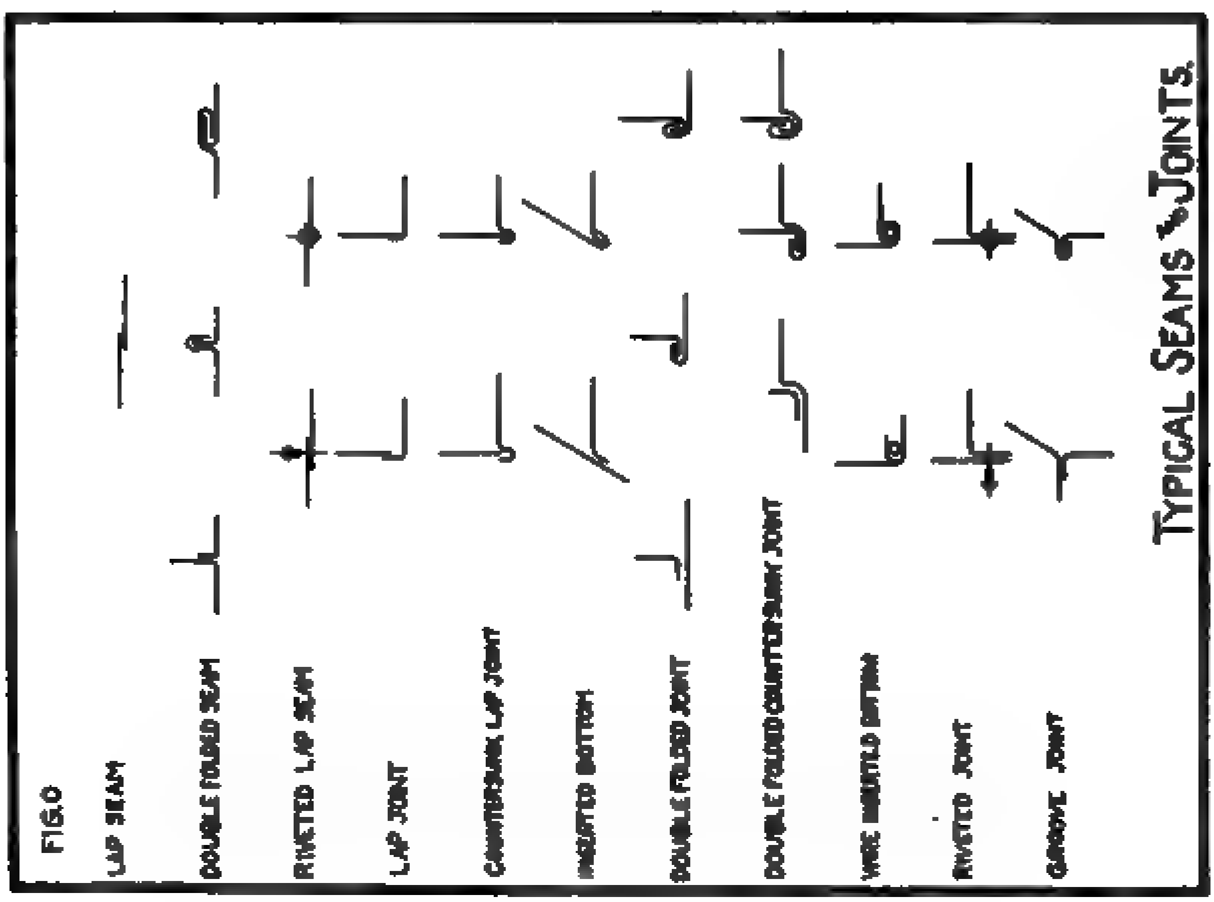


FIG. 0
LAP SEAM
DOUBLE FOLDED SEAM
RIVETED LAP SEAM
LAP JOINT
COUNTERSUNK LAP JOINT
INSERTED BOTTOM
DOUBLE FOLDED JOINT
DOUBLE FOLDED COUNTERSUNK JOINT
WIRE INSERTED BOTTOM
RIVETED JOINT
GROOVE JOINT
TYPICAL SEAMS & JOINTS

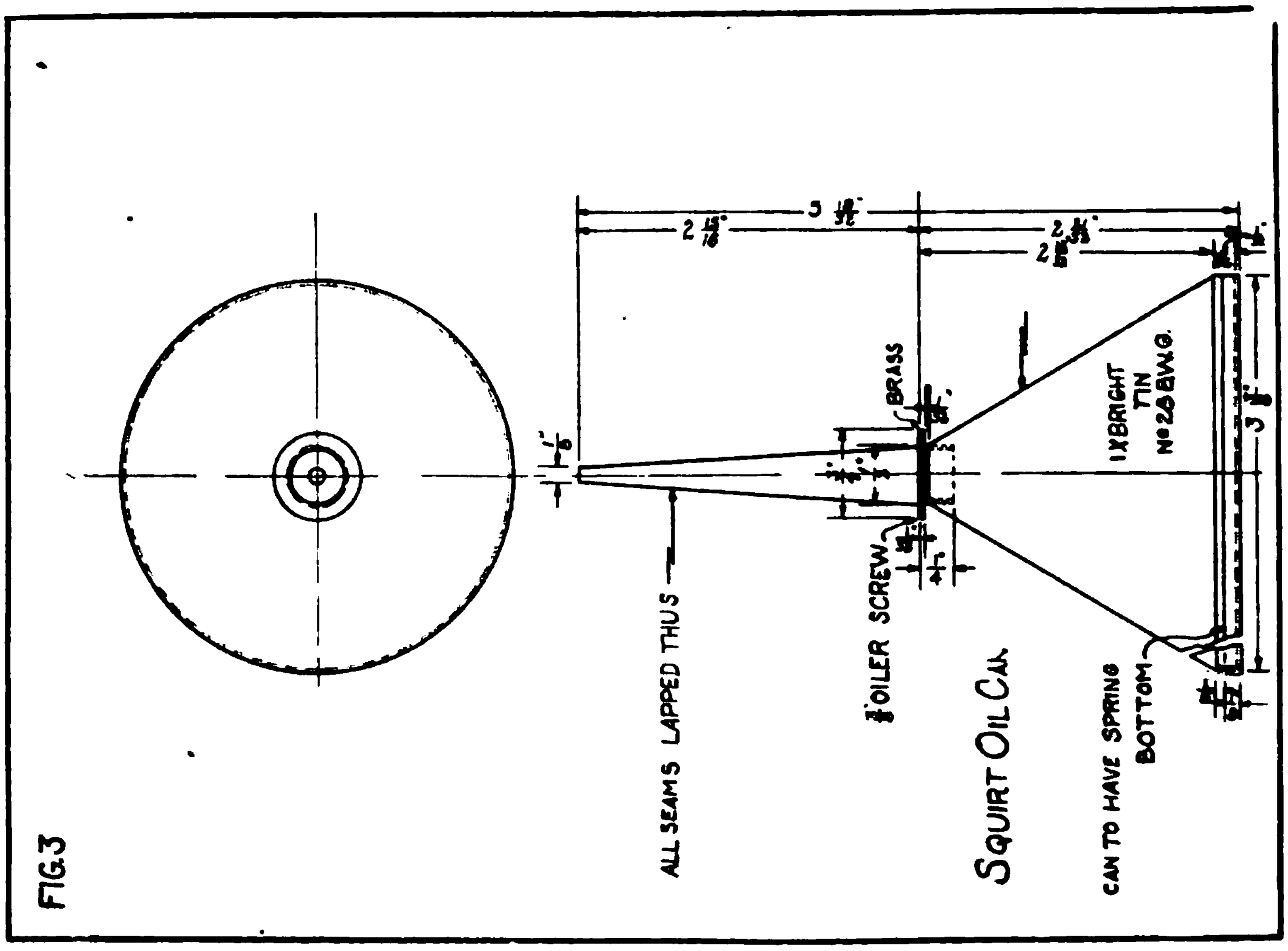

ALL SEAMS LAPPED THUS
1/8 OILER SCREW
BRASS
IX BRIGHT TIN No 28 B.W.G.
CAN TO HAVE SPRING BOTTOM
SQUIRT OIL CAN

FIG. 3

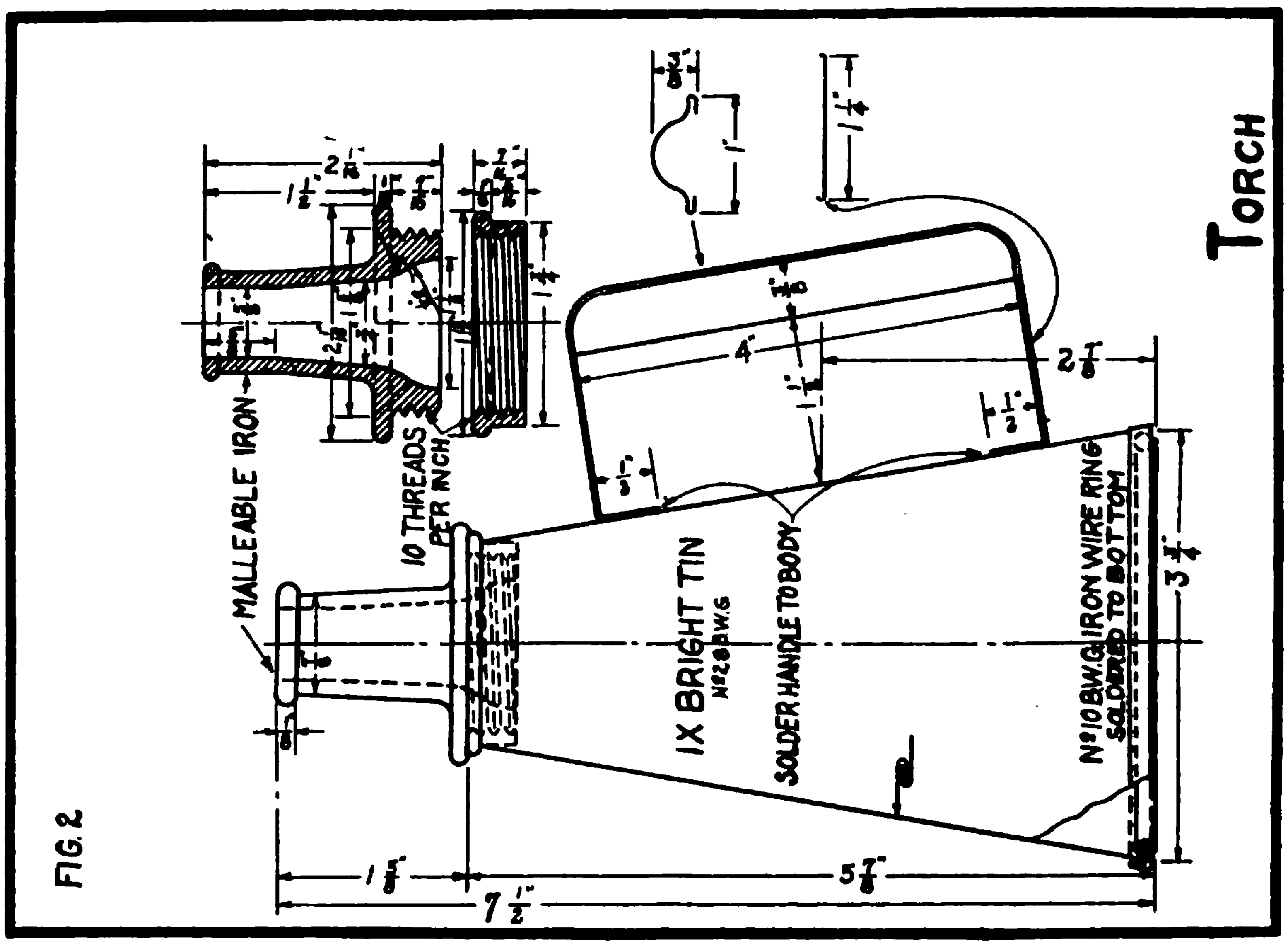
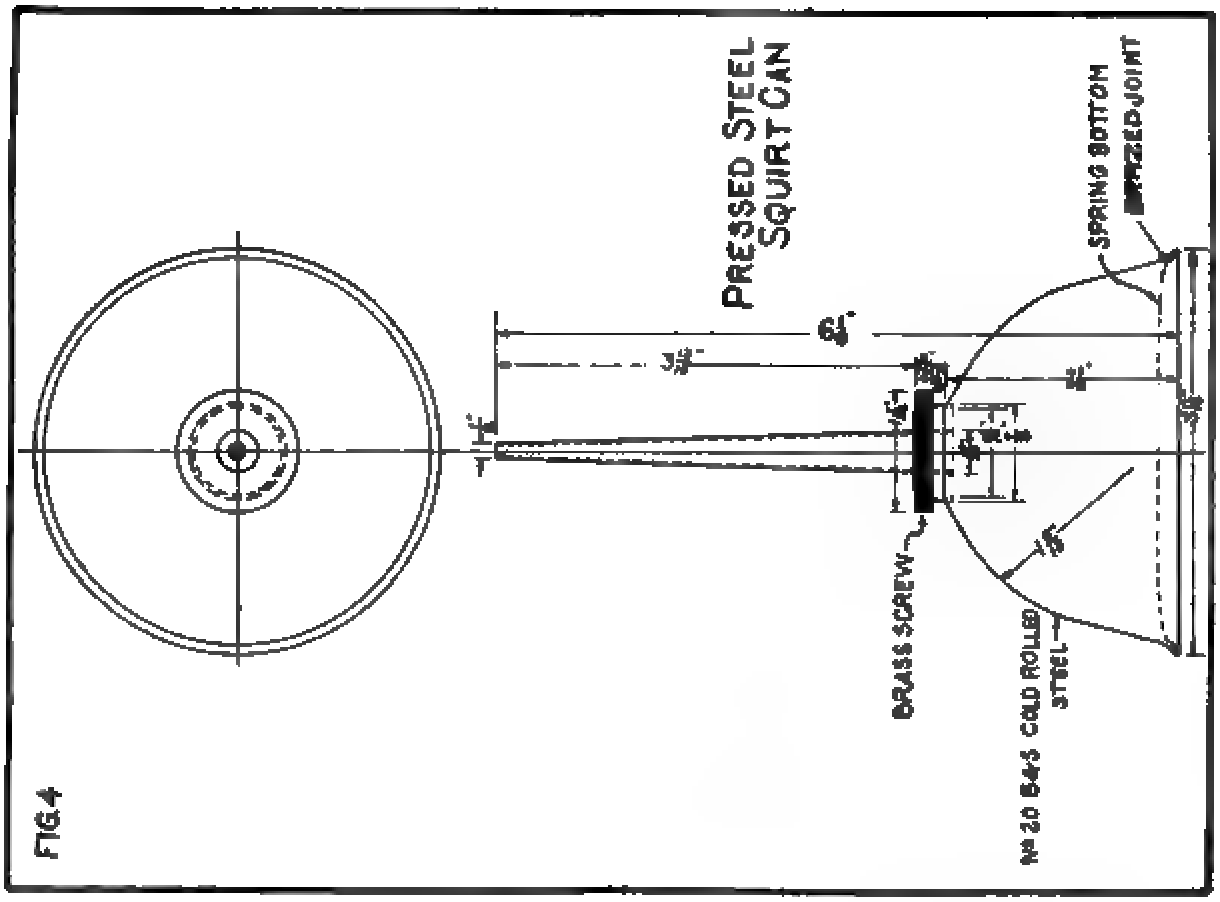

MALLEABLE IRON
10 THREADS PER INCH
IX BRIGHT TIN No 28 B.W.G.
SOLDER HANDLE TO BODY
No 10 B.W.G. IRON WIRE RING SOLDERED TO BOTTOM
TORCH

FIG. 2


PRESSED STEEL SQUIRT CAN
SPRING BOTTOM
BRAZED JOINT
BRASS SCREW
Nº 20 B&S COLD ROLLED STEEL
FIG. 4

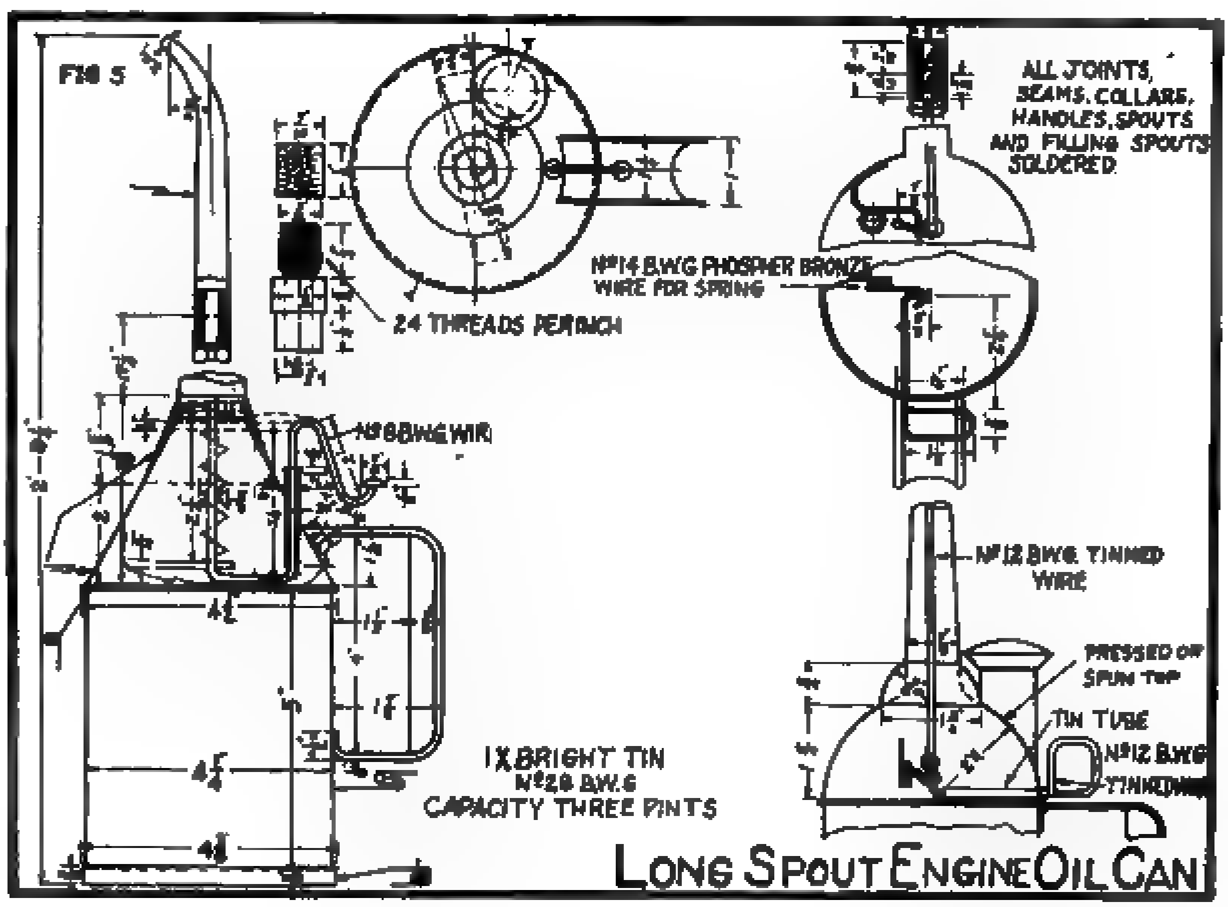
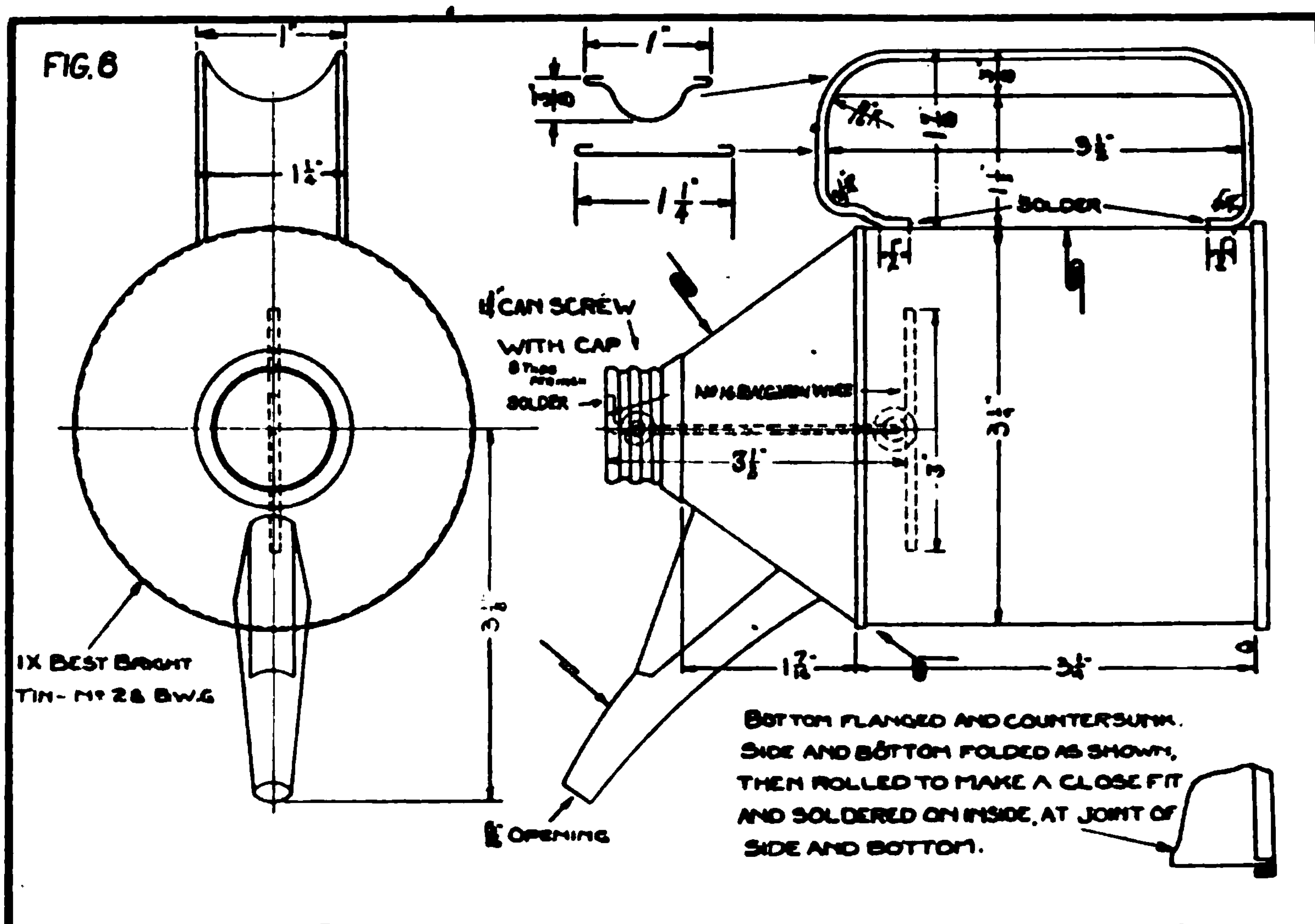


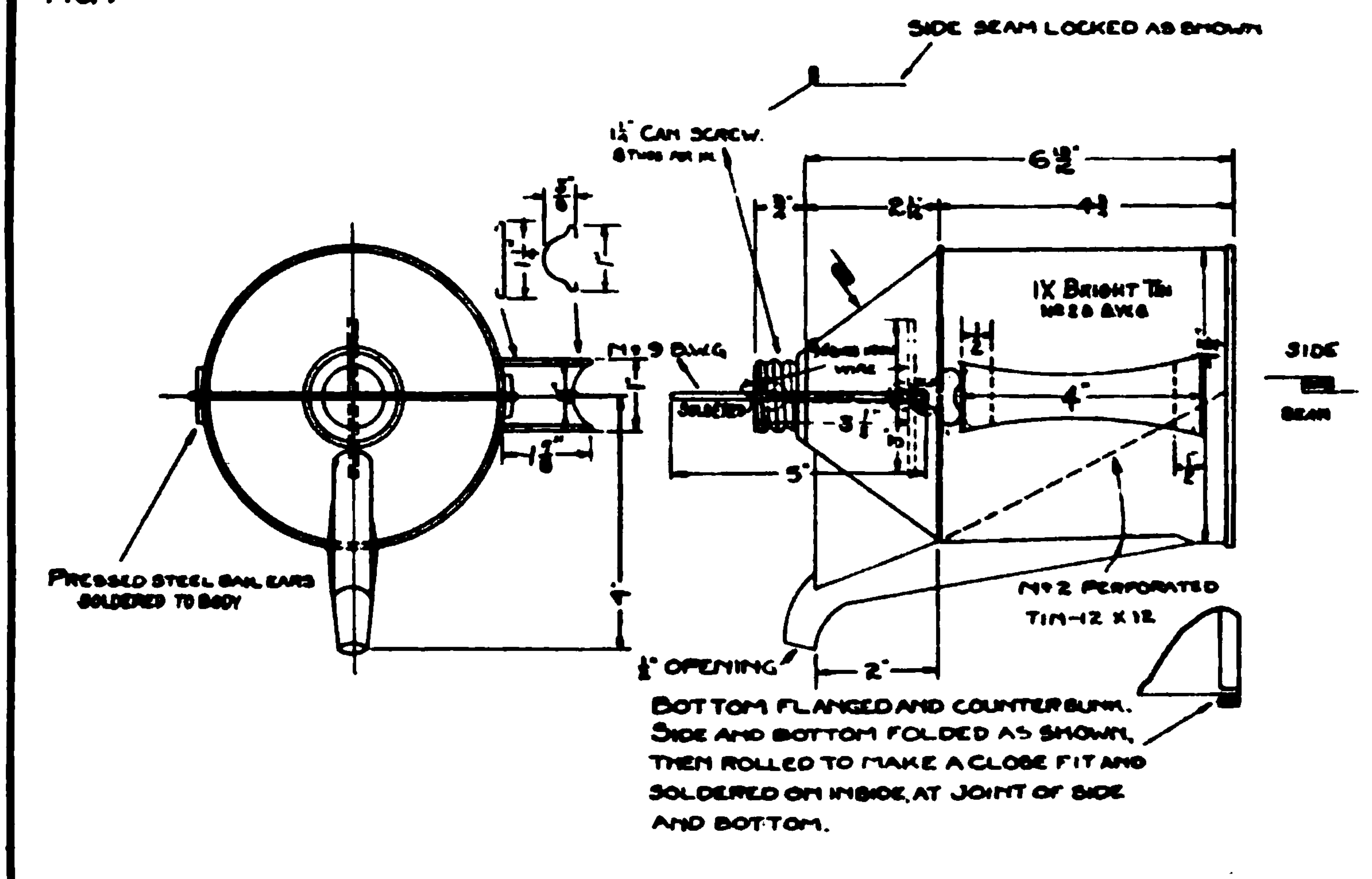
FIG 5
24 THREADS PER INCH
Nº 8 B.W.G. WIRE
ALL JOINTS, SEAMS, COLLARS, HANDLES, SPOUTS AND FILLING SPOUTS SOLDERED
Nº 14 B.W.G PHOSPHER BRONZE WIRE FOR SPRING
Nº 12 B.W.G. TINNED WIRE
PRESSED OR SPUN TOP
TIN TUBE
Nº 12 B.W.G TINNED WIRE
IX BRIGHT TIN
Nº 28 B.W.G
CAPACITY THREE PINTS
LONG SPOUT ENGINE OIL CAN

FIG. 6



LAMP FILLER AND ONE PINT SIGNAL OIL CAN

FIG. 7



THREE PINT VALVE OIL CAN.

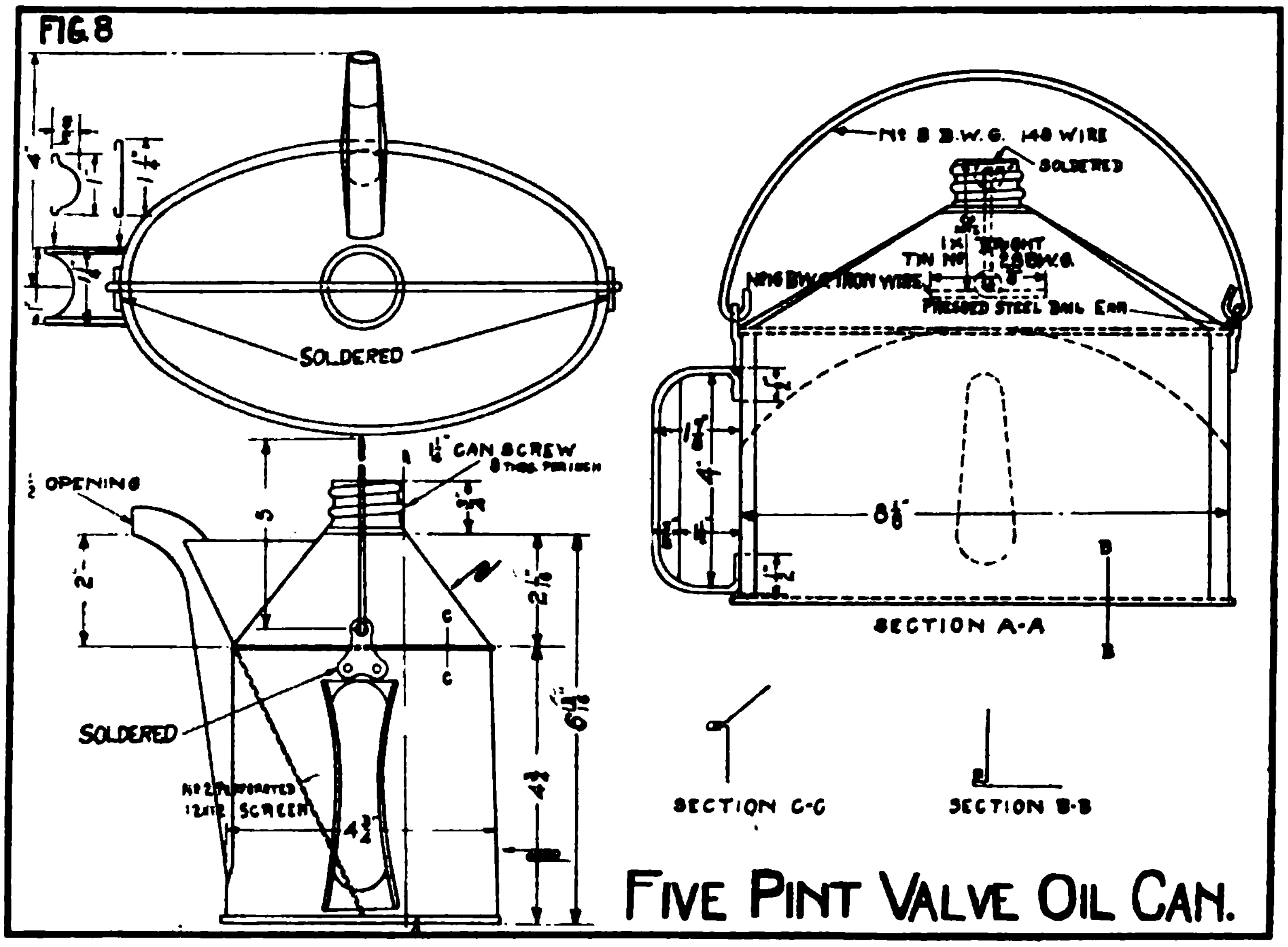


FIG. 8
SOLDERED
CAN SCREW
OPENING
SOLDERED
SCREEN
SECTION A-A
SECTION C-C
SECTION B-B
FIVE PINT VALVE OIL CAN.

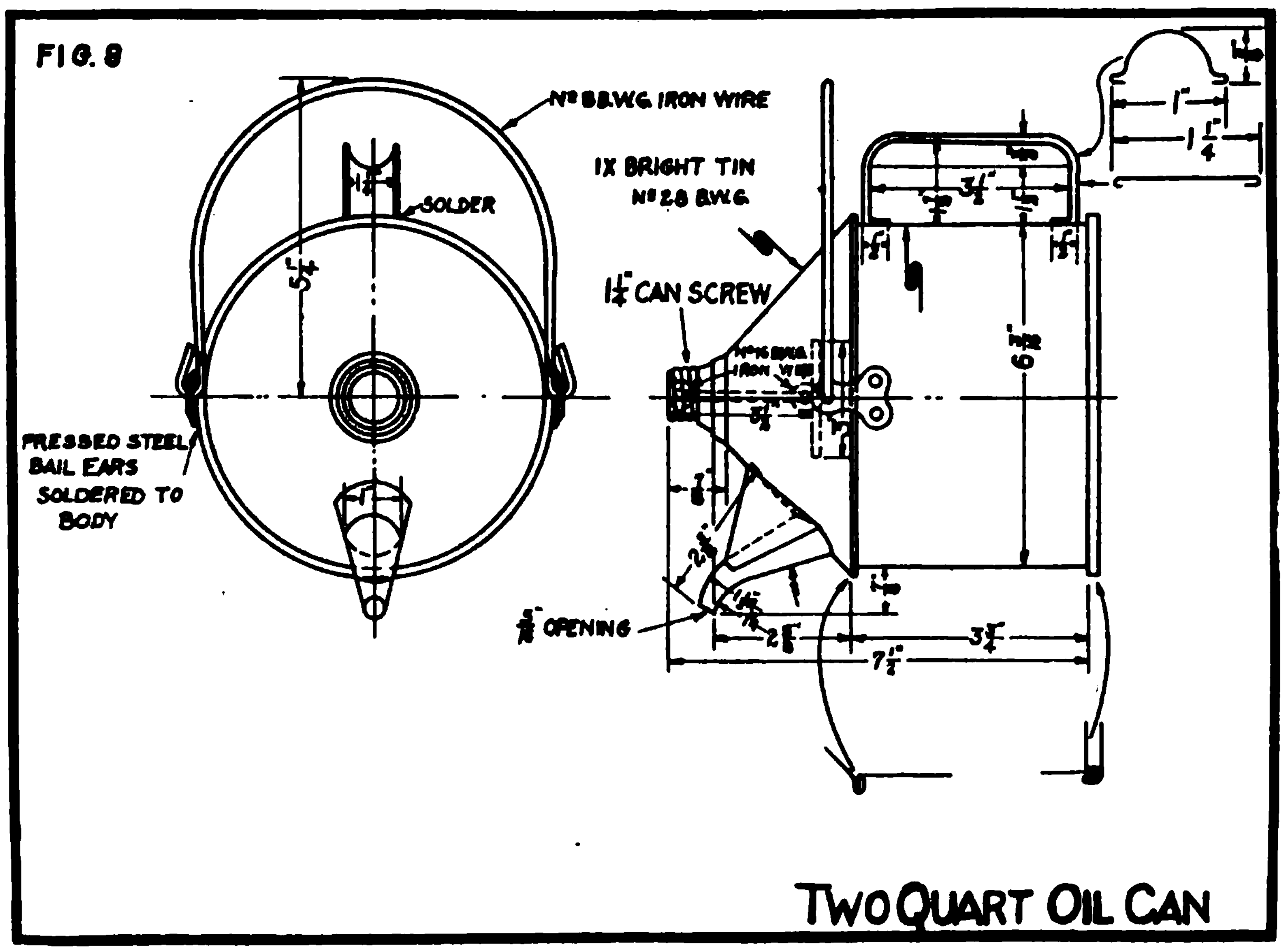
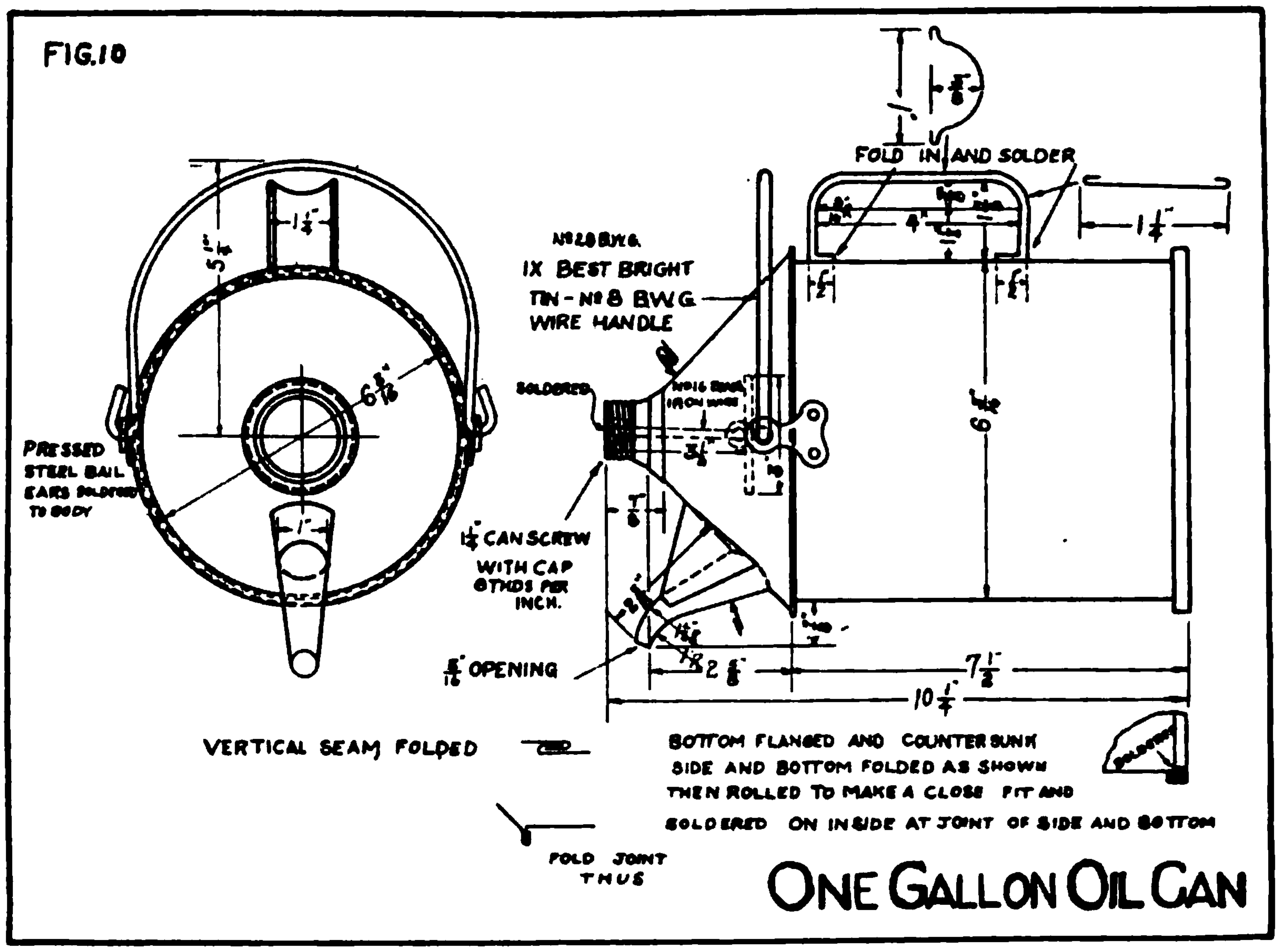


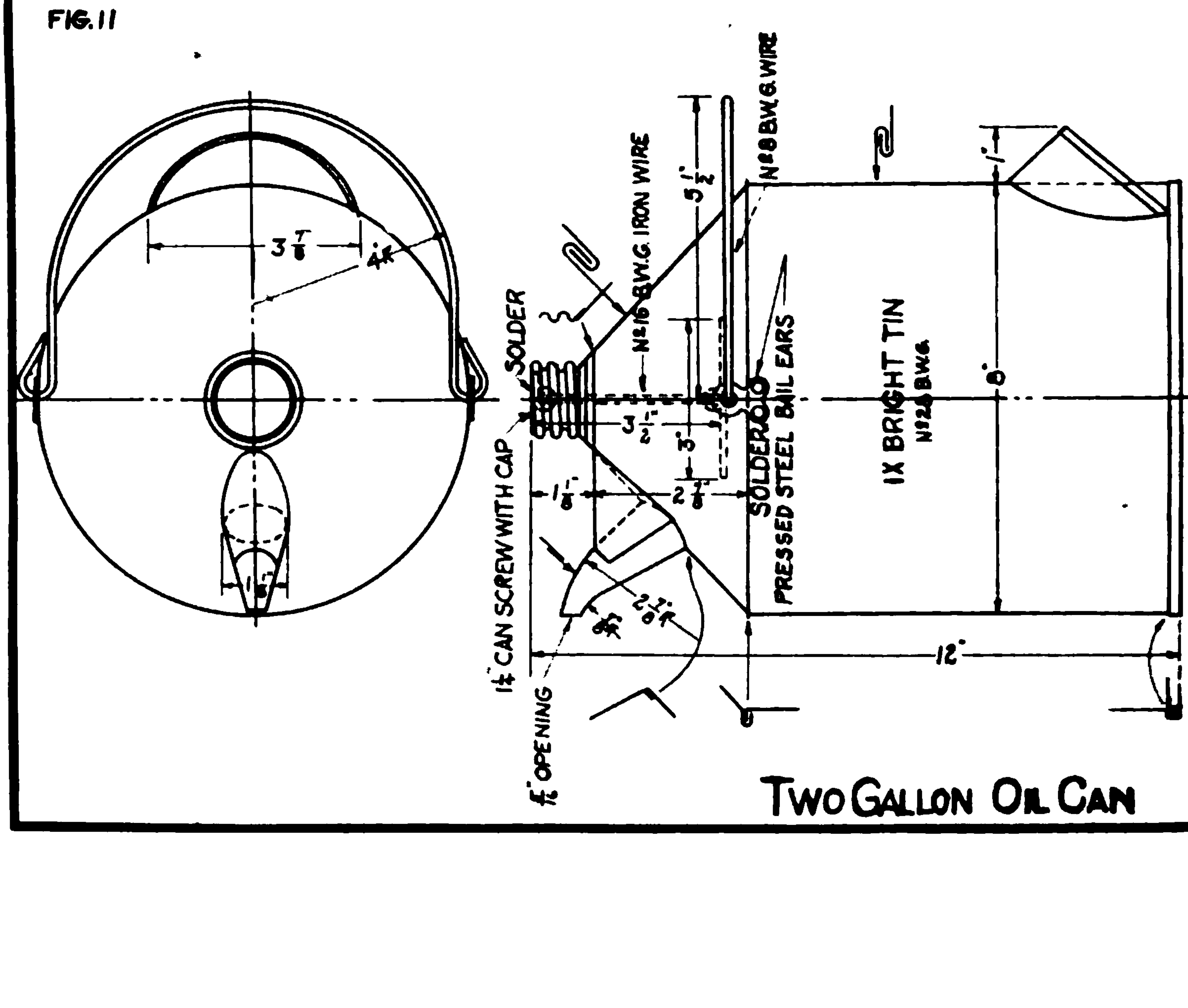
FIG. 9
No 8 B.W.G. IRON WIRE
SOLDER
PRESSED STEEL BAIL EARS SOLDERED TO BODY
IX BRIGHT TIN No 28 B.W.G.
$1\frac{1}{4}$" CAN SCREW
OPENING
TWO QUART OIL CAN

FIG. 10



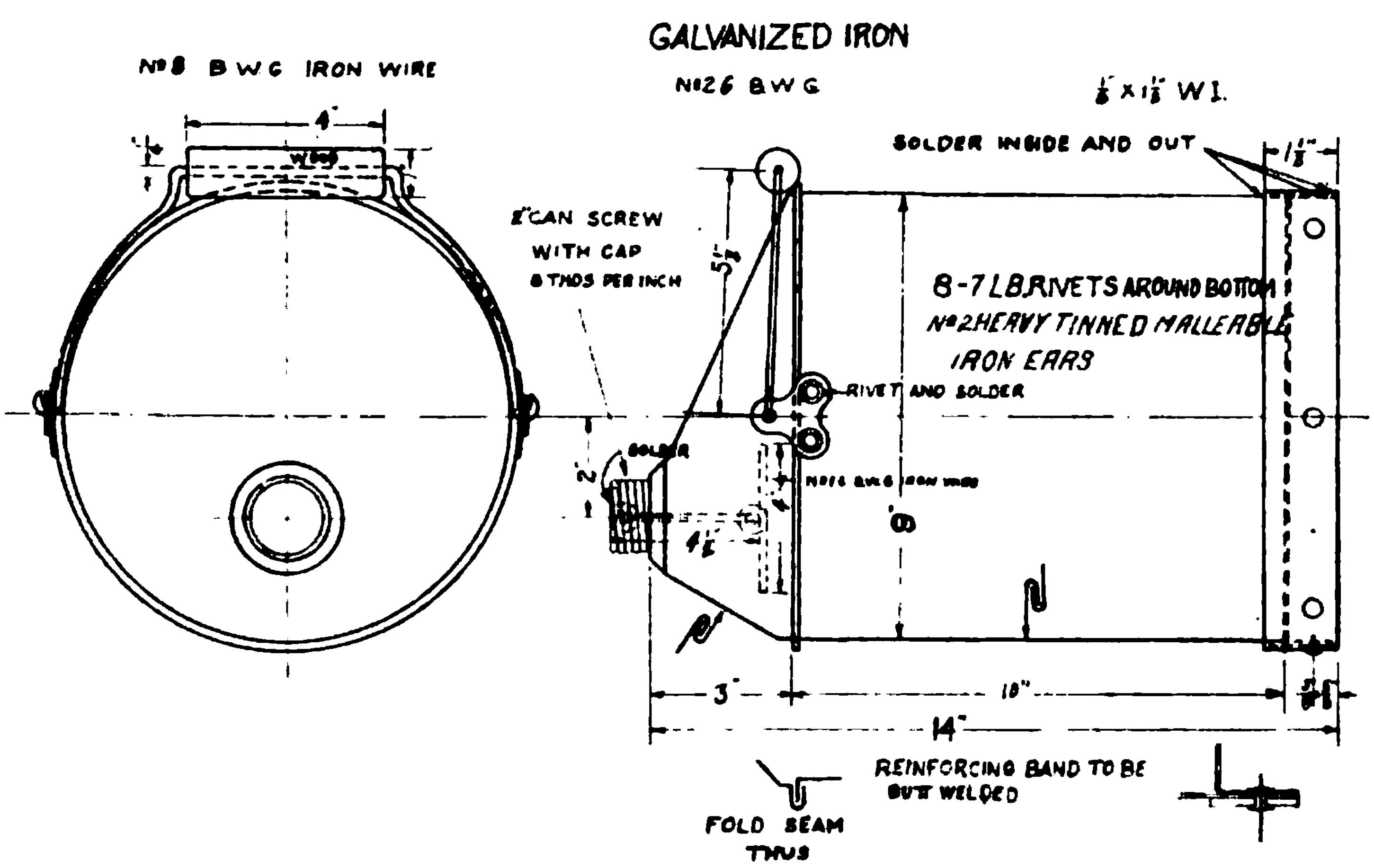
ONE GALLON OIL CAN

FIG. 11



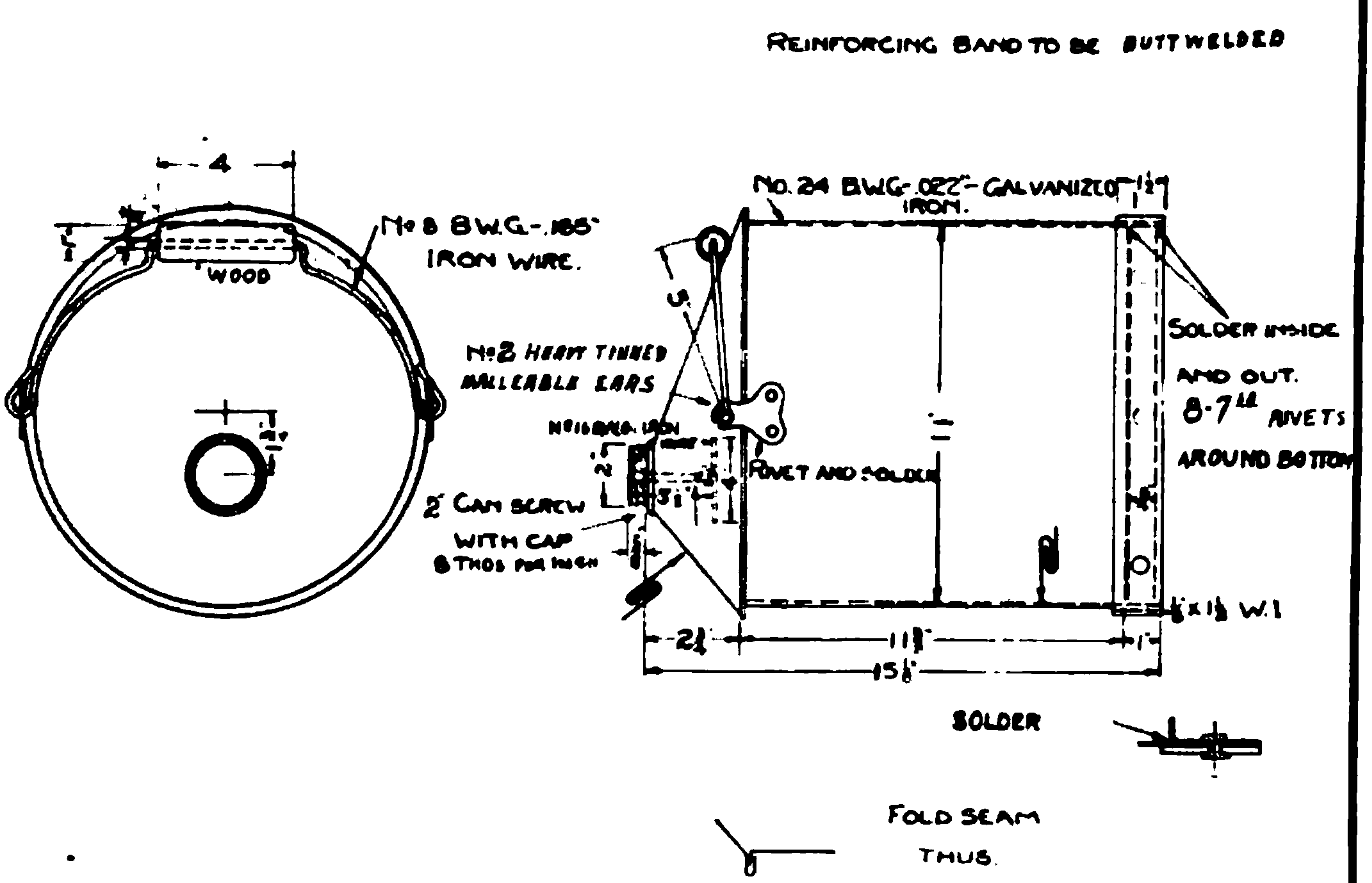
TWO GALLON OIL CAN

FIG. 12



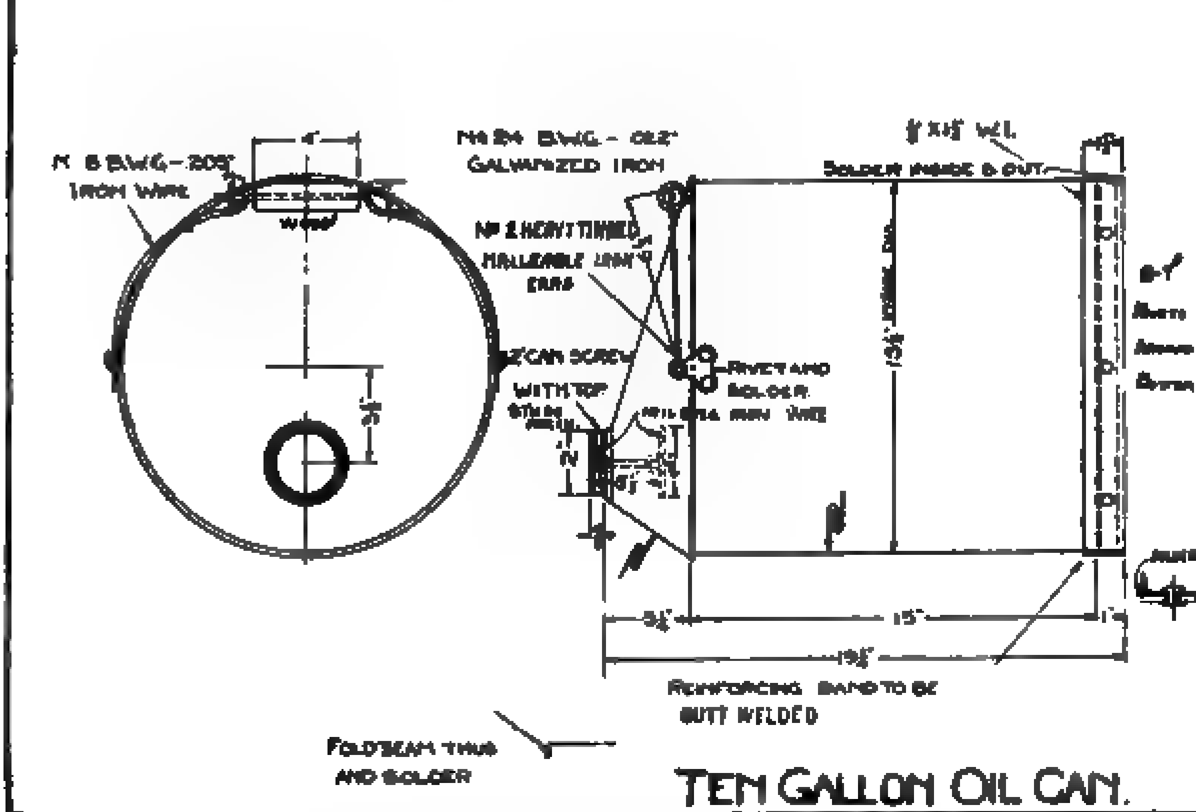
THREE GALLON OIL CAN

FIG. 13



FIVE GALLON OIL CAN.

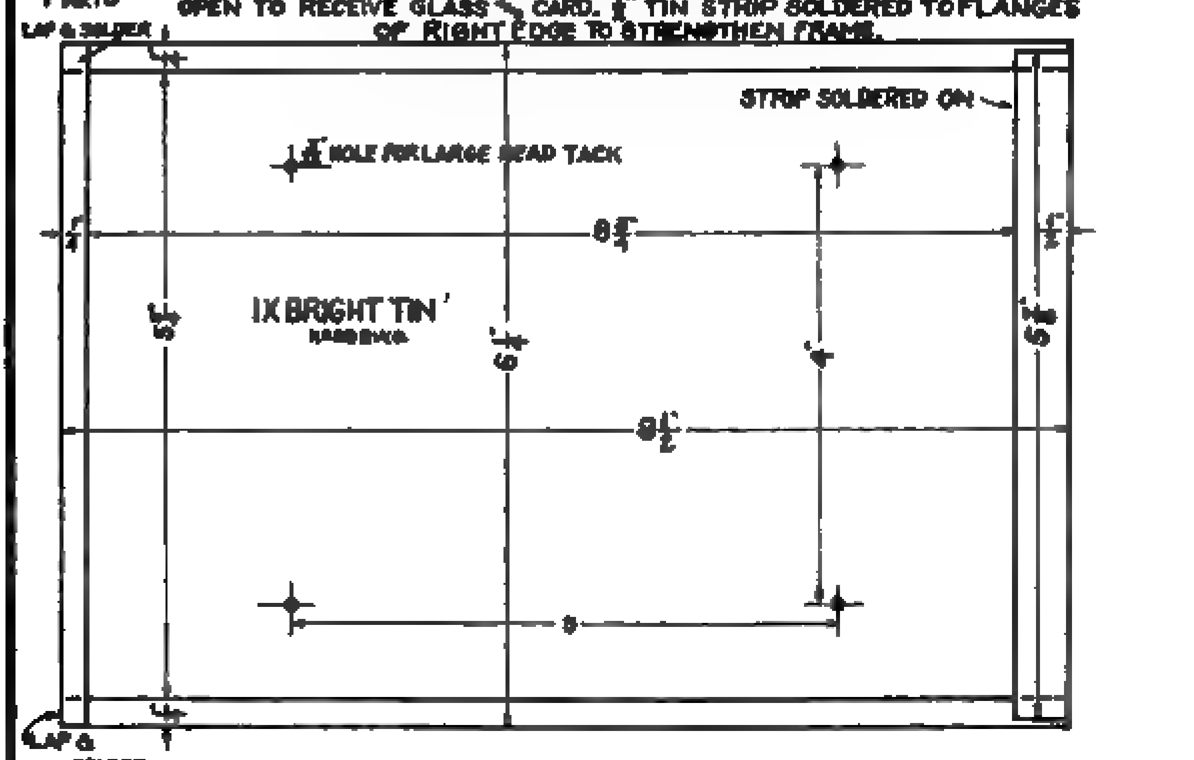
FIG.14



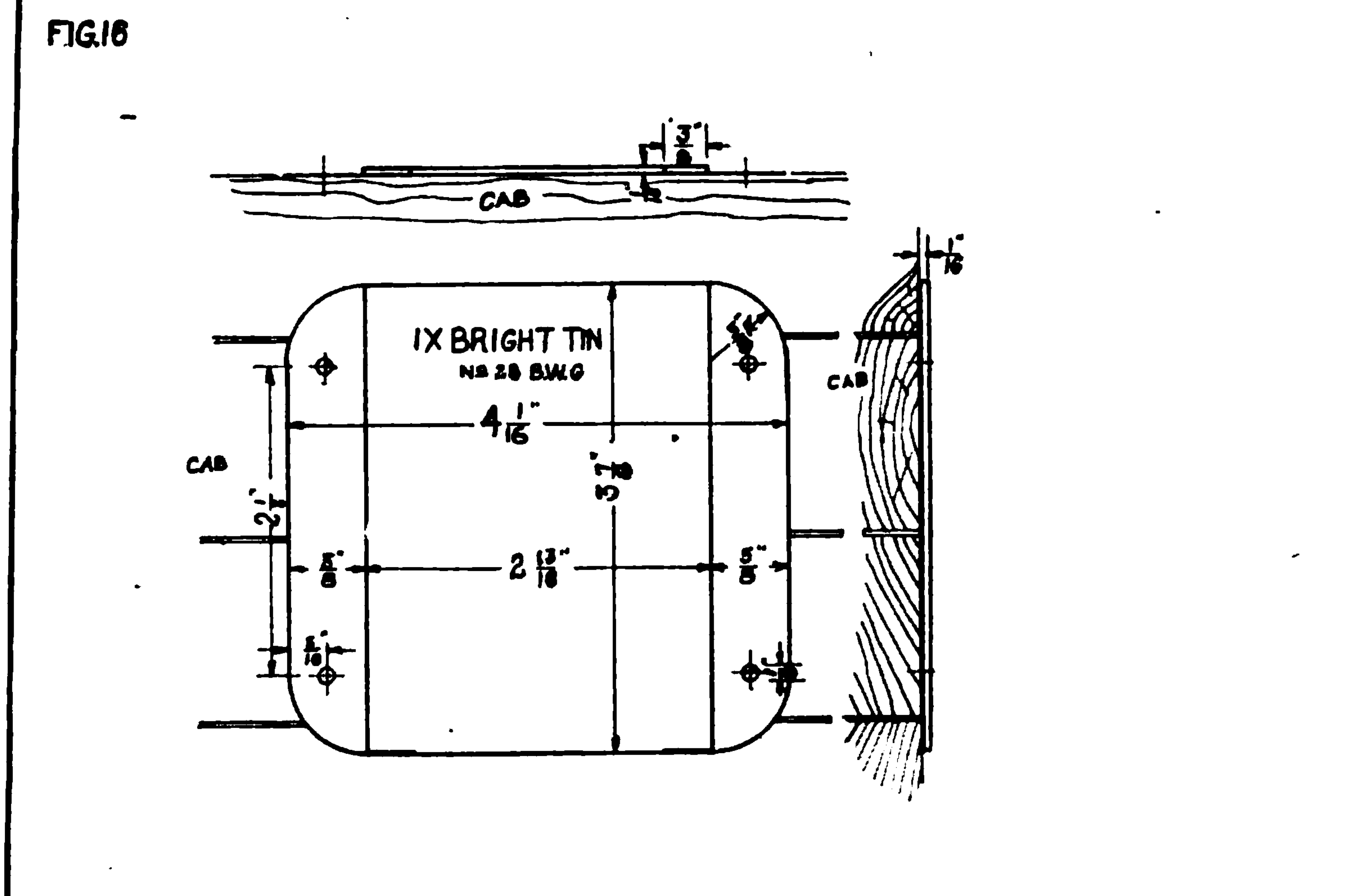
TEN GALLON OIL CAN.

FIG.15

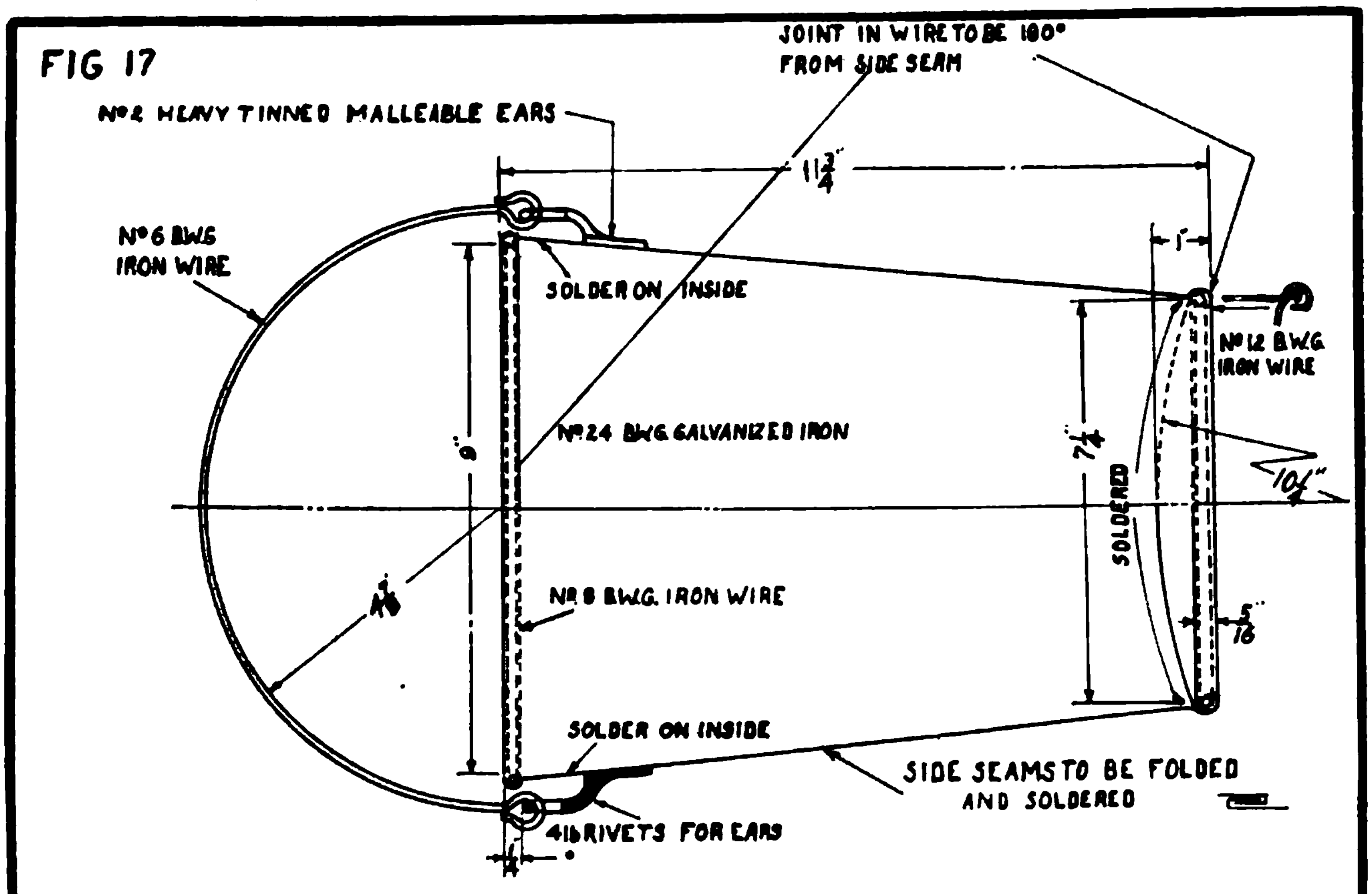
TOP BOTTOM & LEFT END BENT AS SHOWN TO FORM FRAME. RIGHT END LEFT OPEN TO RECEIVE GLASS & CARD. ⅛" TIN STRIP SOLDERED TO FLANGES OF RIGHT EDGE TO STRENGTHEN FRAME.



BOILER INSPECTION CARD CASE



WASH-OUT CARD CASE



TANK BUCKET

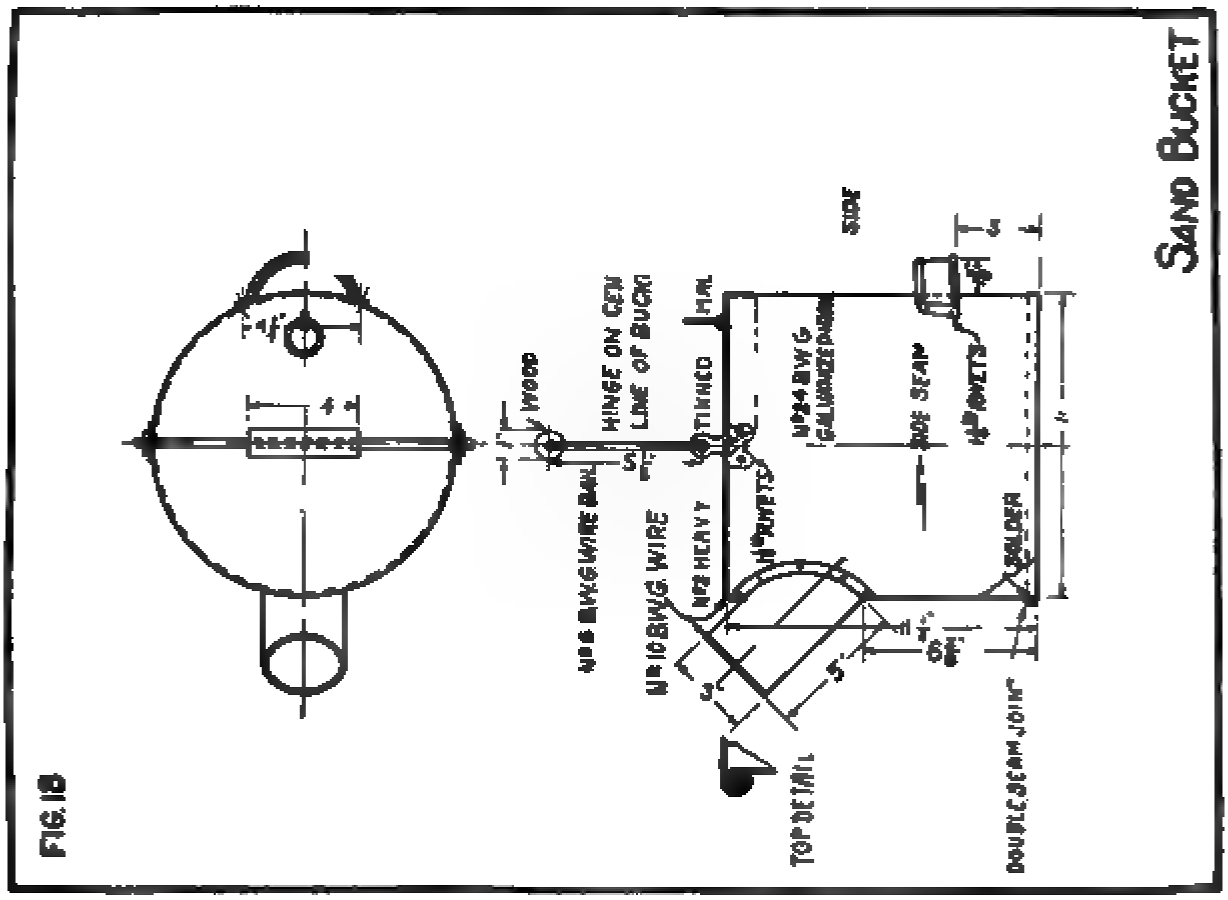


FIG. 18

SAND BUCKET

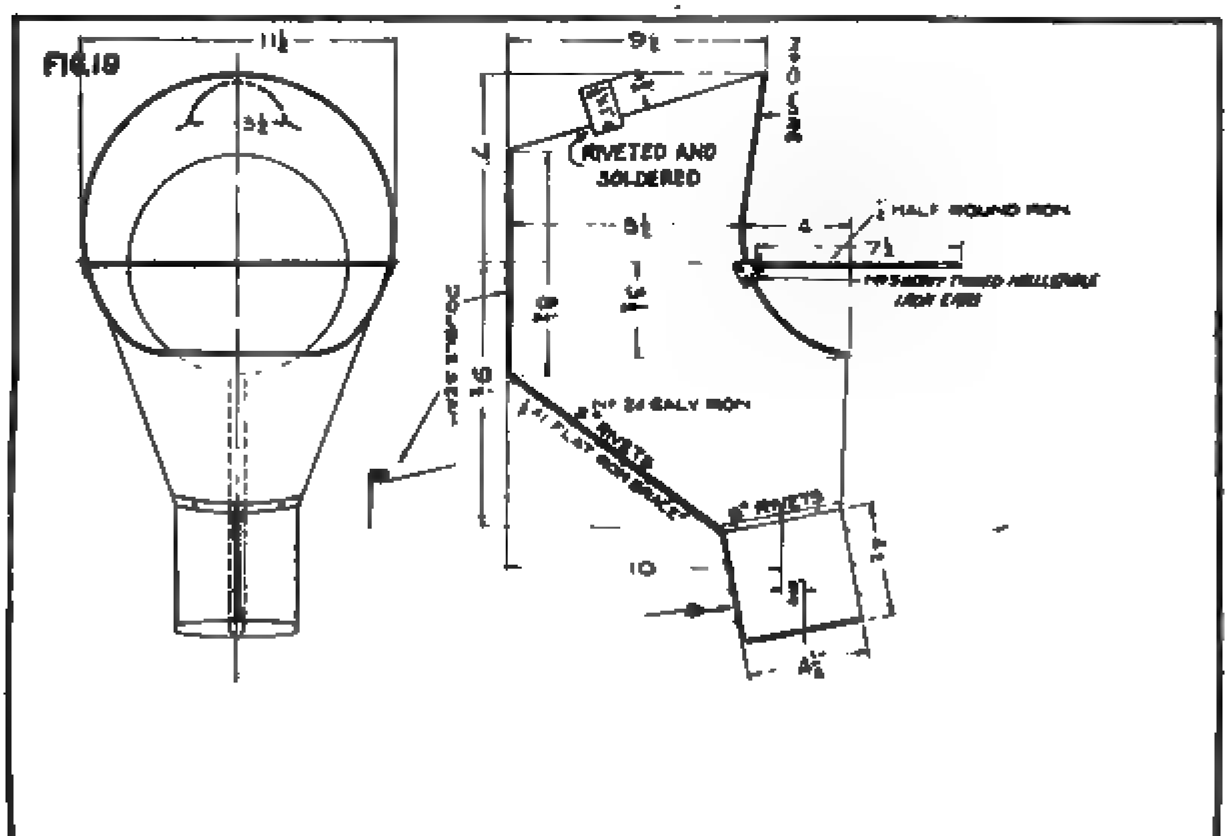
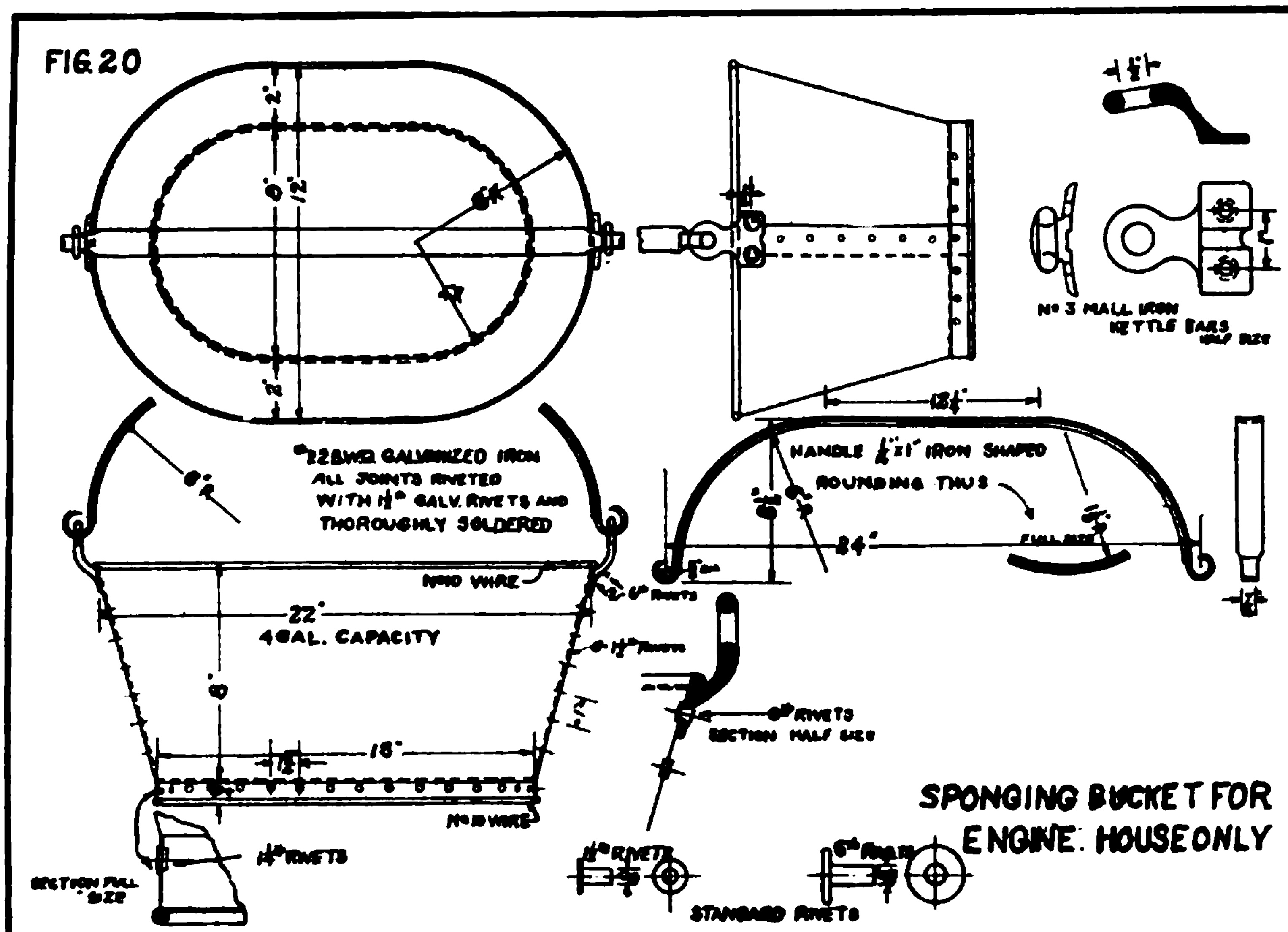


FIG. 19

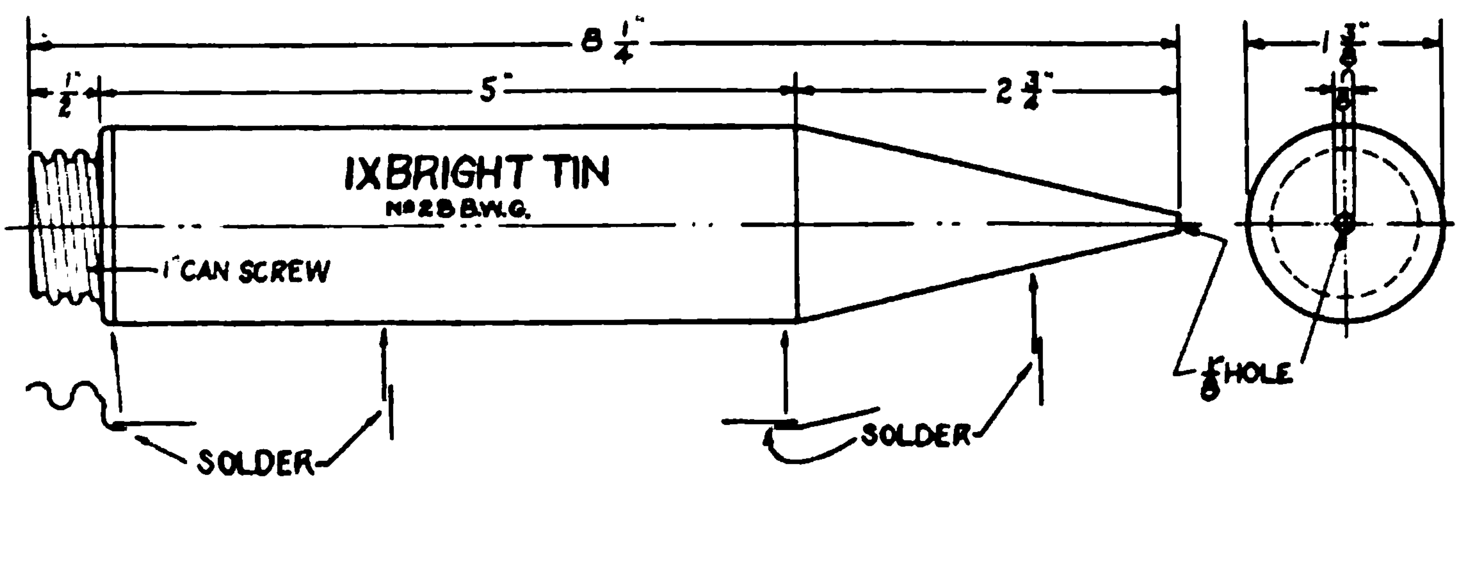
SAND BUCKET

FIG. 20



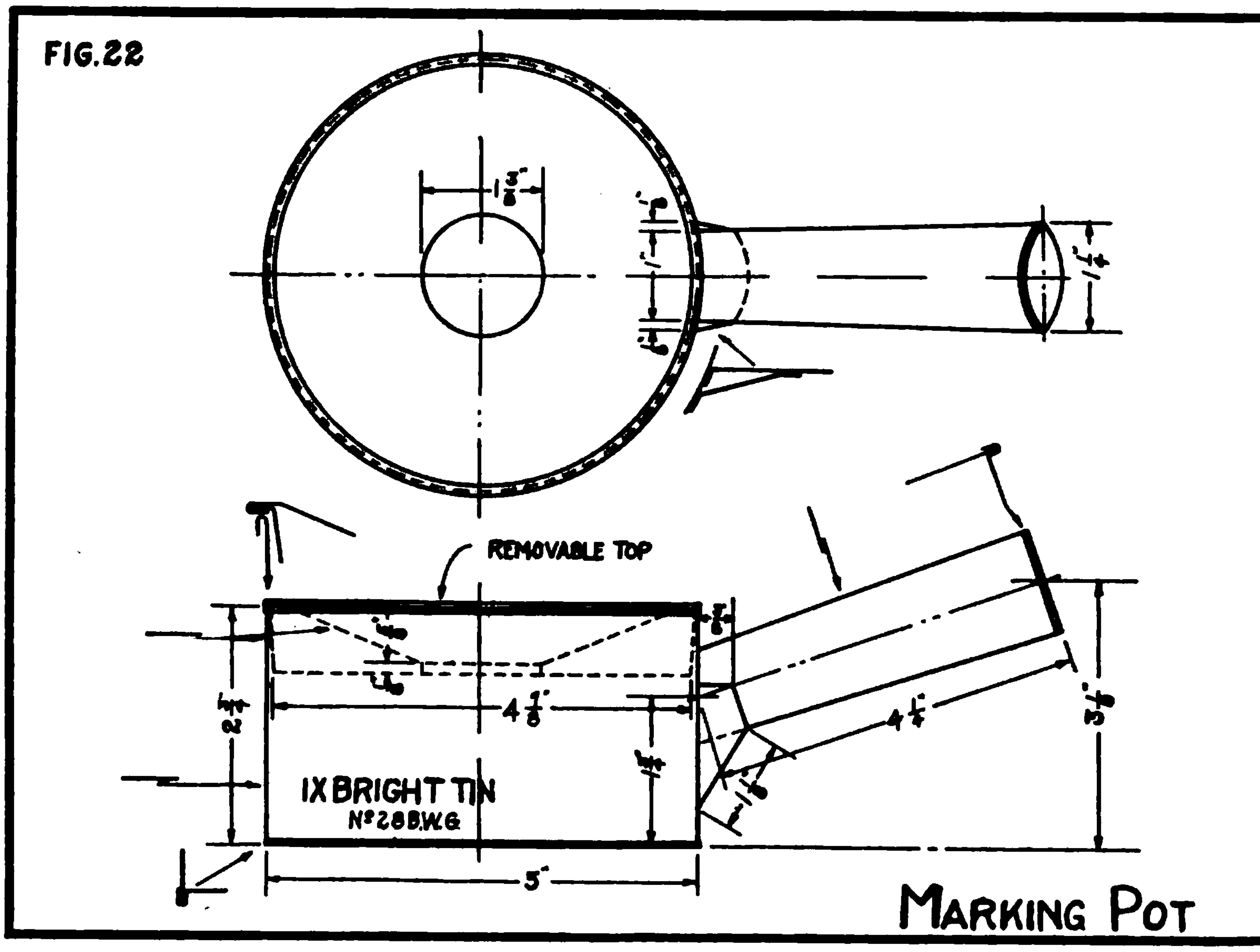
SPONGING BUCKET FOR ENGINE HOUSE ONLY

FIG. 21



ONE POUND EMERY CAN

FIG. 22


REMOVABLE TOP
IX BRIGHT TIN
Nº 28 B.W.G.
5"
MARKING POT

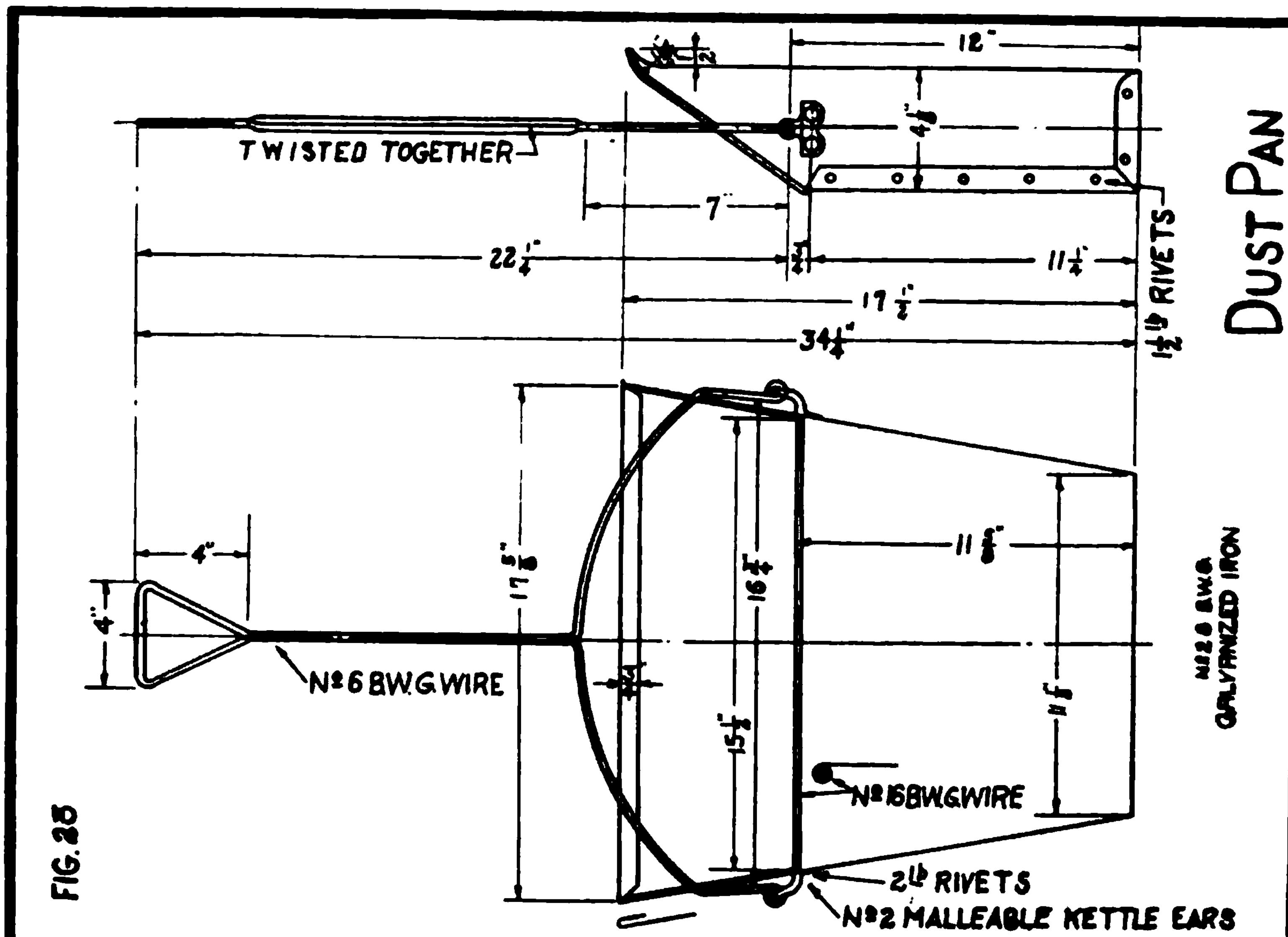

TWISTED TOGETHER
12"
7"
22 1/4"
11 1/4"
17 1/2"
34 1/4"
1 1/2 lb RIVETS
DUST PAN
4"
Nº 6 B.W.G. WIRE
Nº 16 B.W.G. WIRE
2 lb RIVETS
Nº 2 MALLEABLE KETTLE EARS
Nº 28 B.W.G. GALVANIZED IRON

FIG. 23

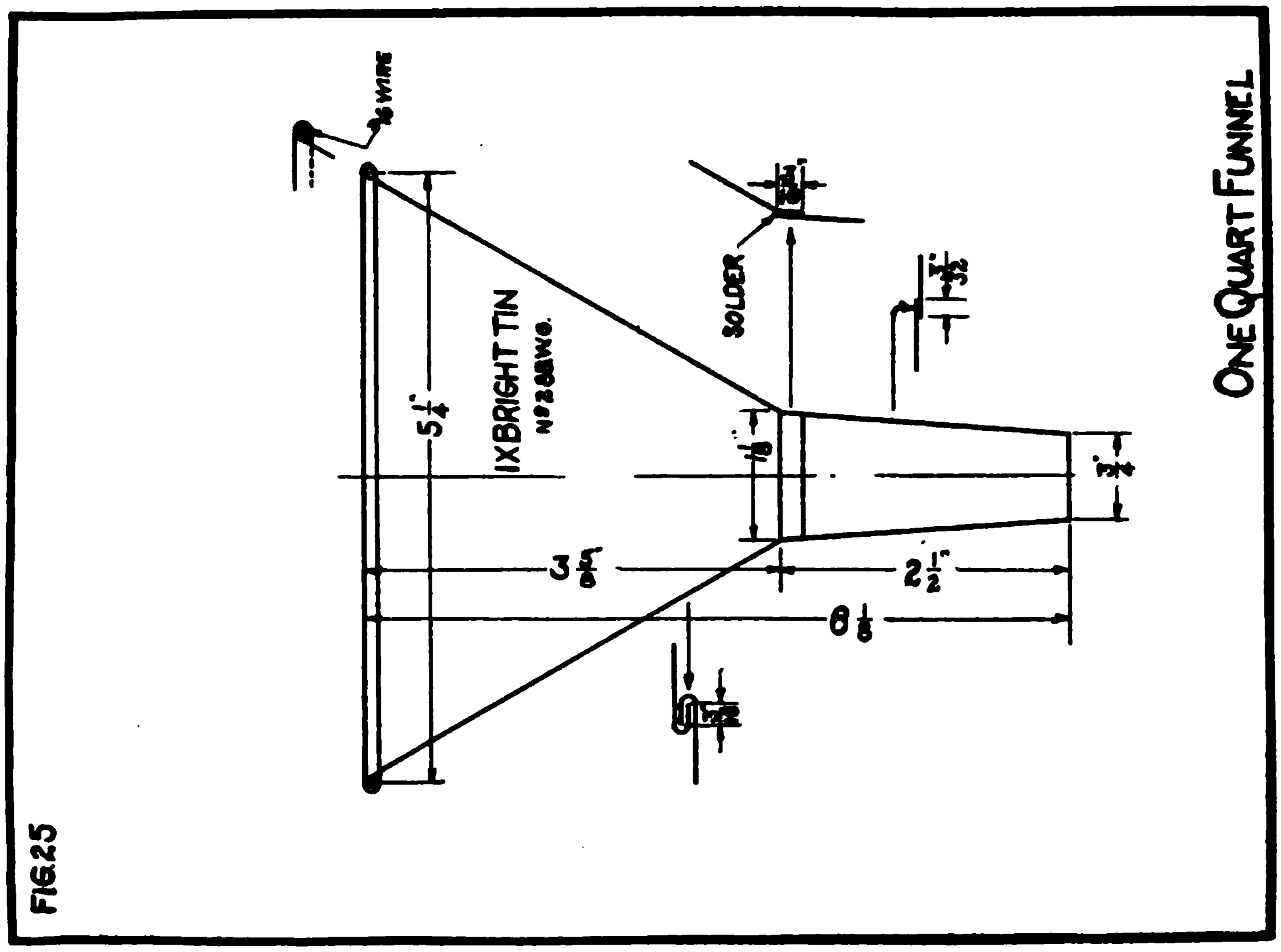


FIG.25 ONE QUART FUNNEL

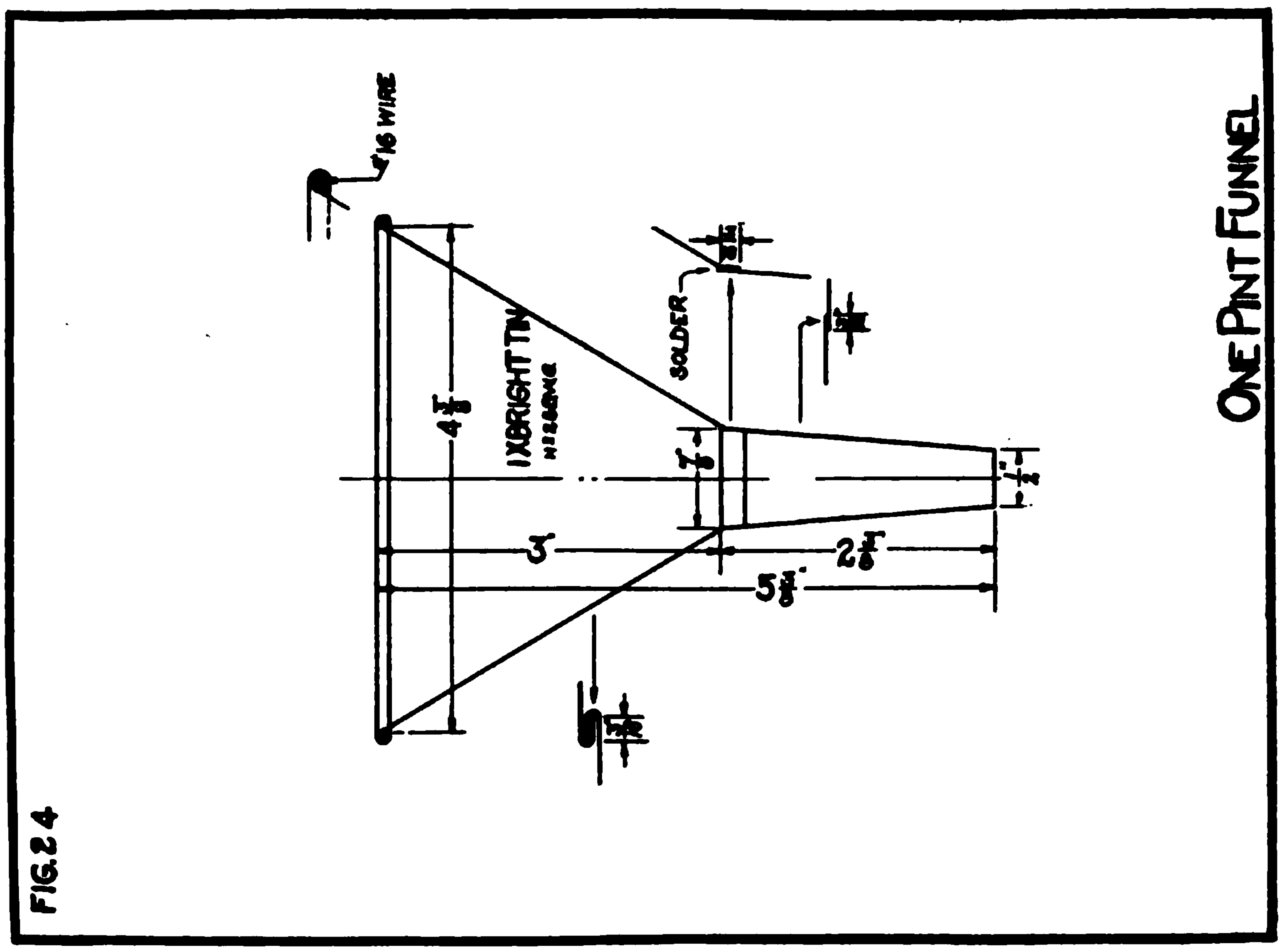


FIG.24 ONE PINT FUNNEL

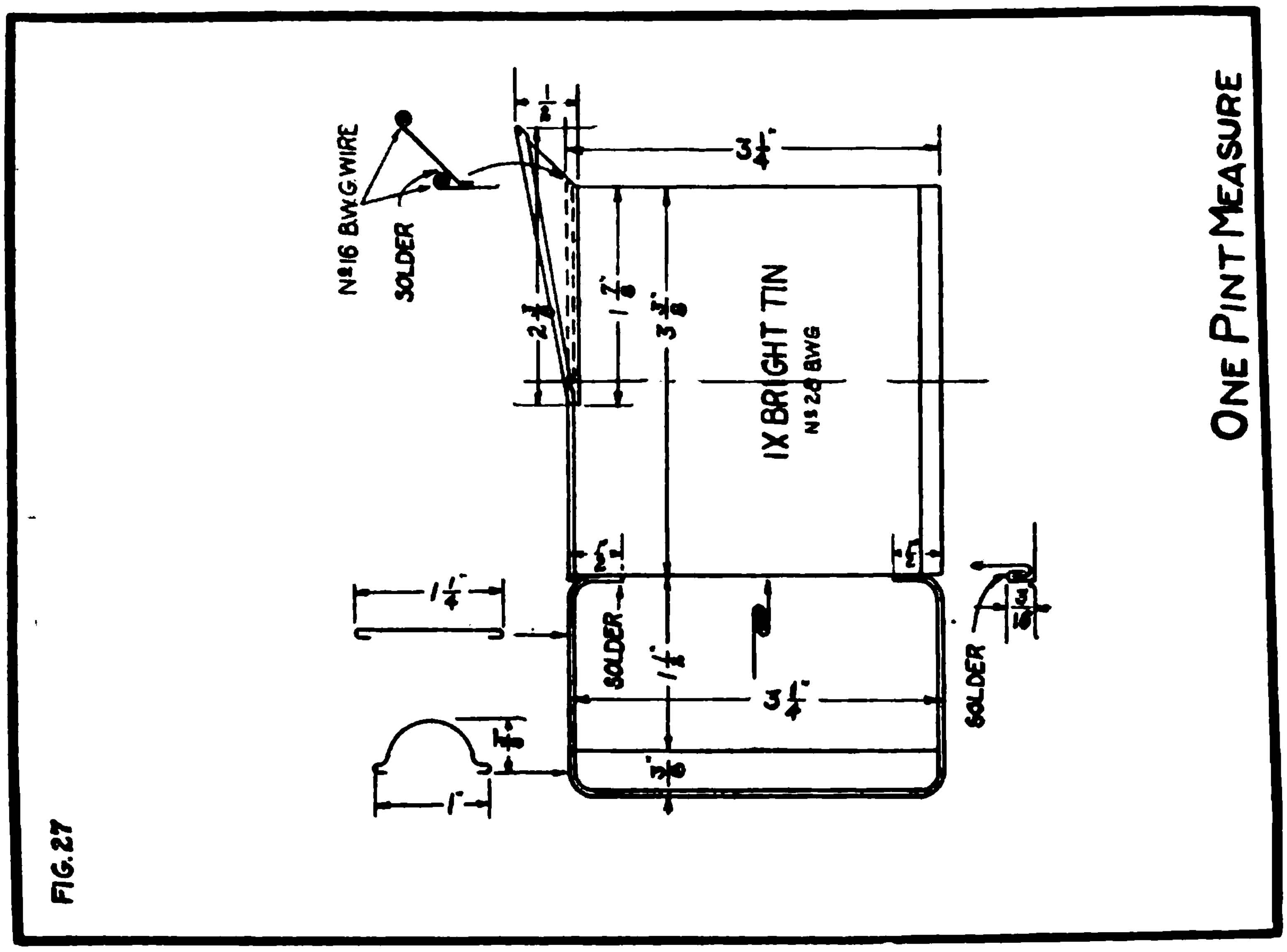


FIG. 27 ONE PINT MEASURE

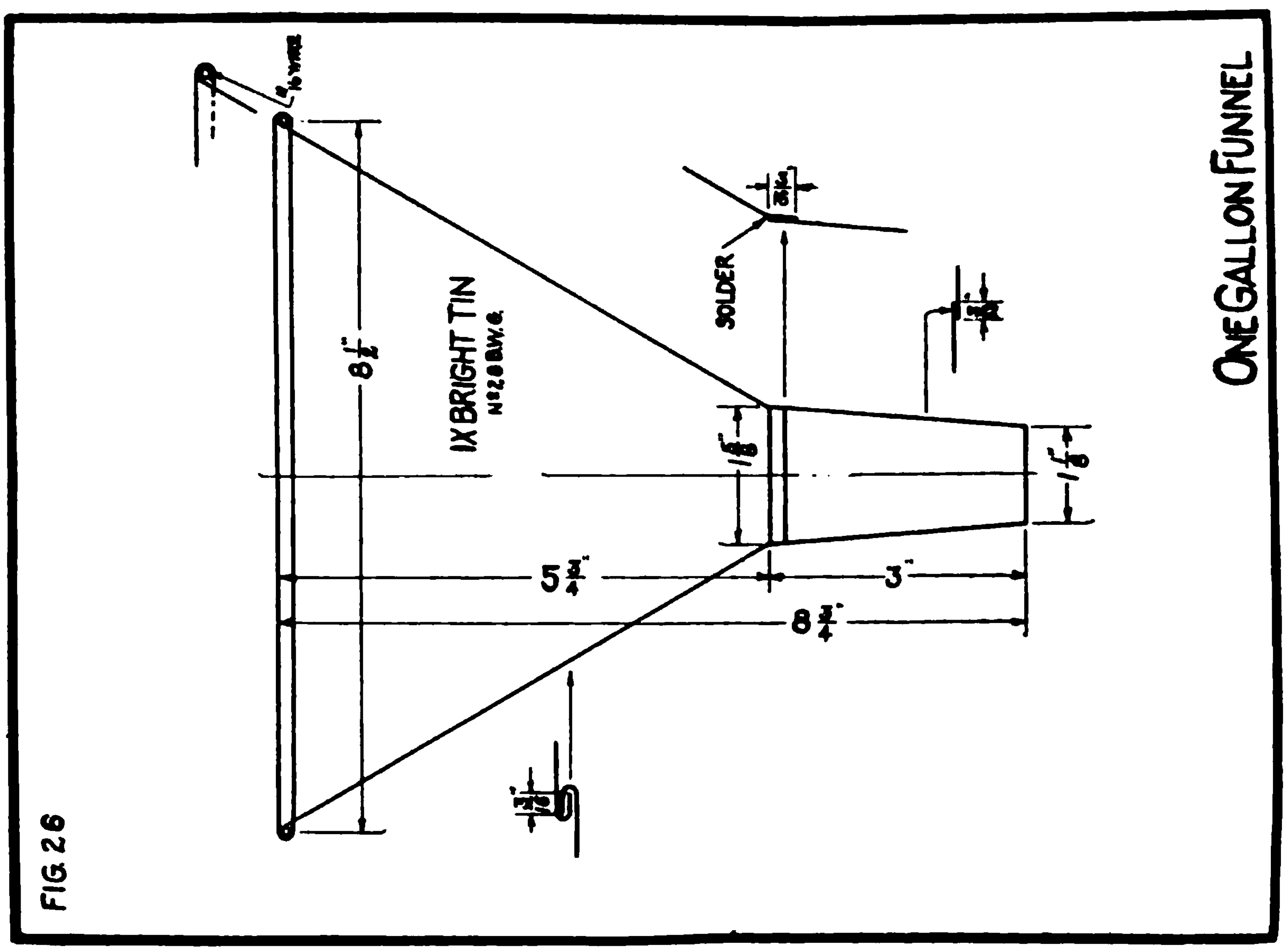


FIG. 26 ONE GALLON FUNNEL

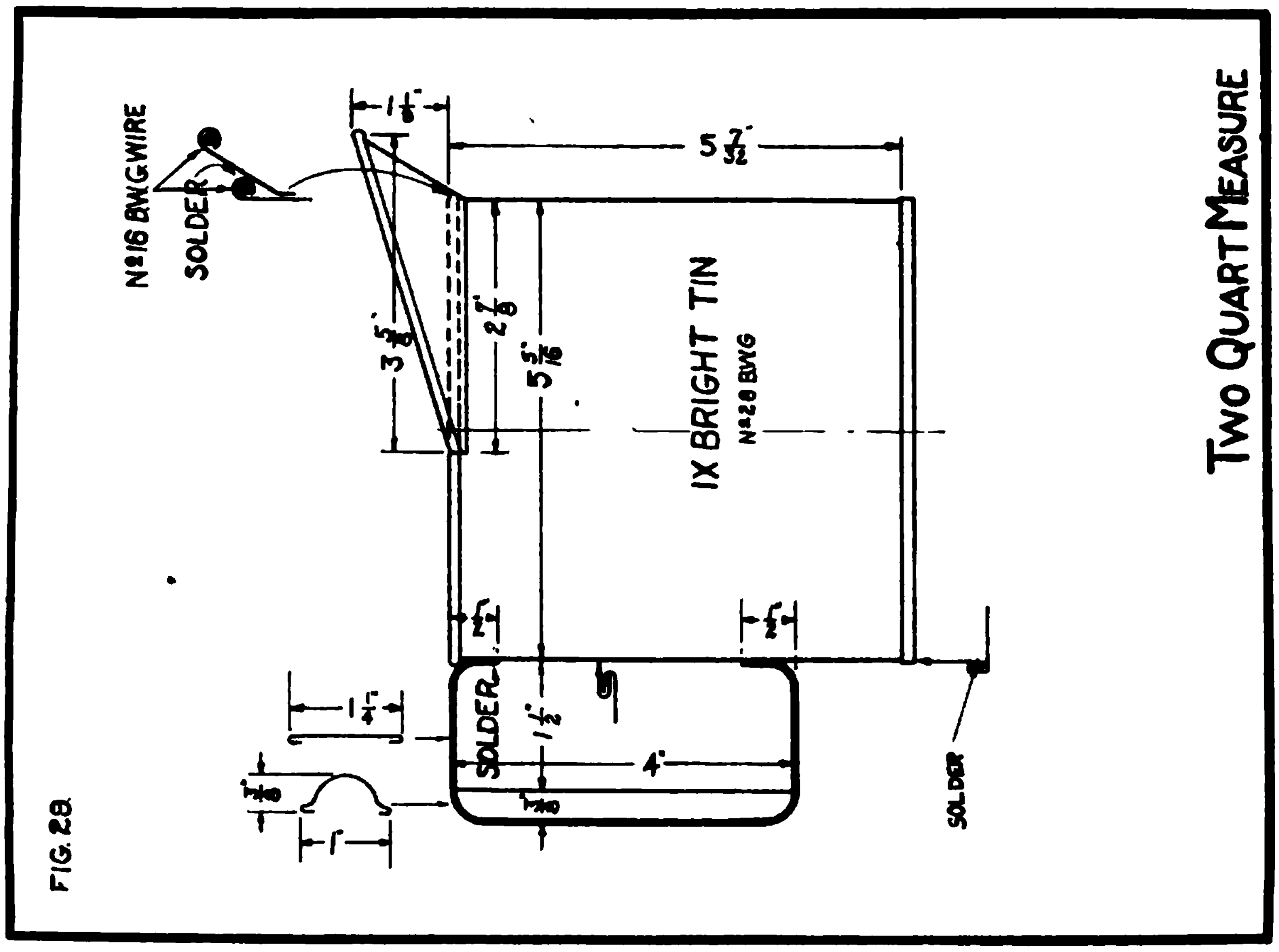


FIG. 28

TWO QUART MEASURE

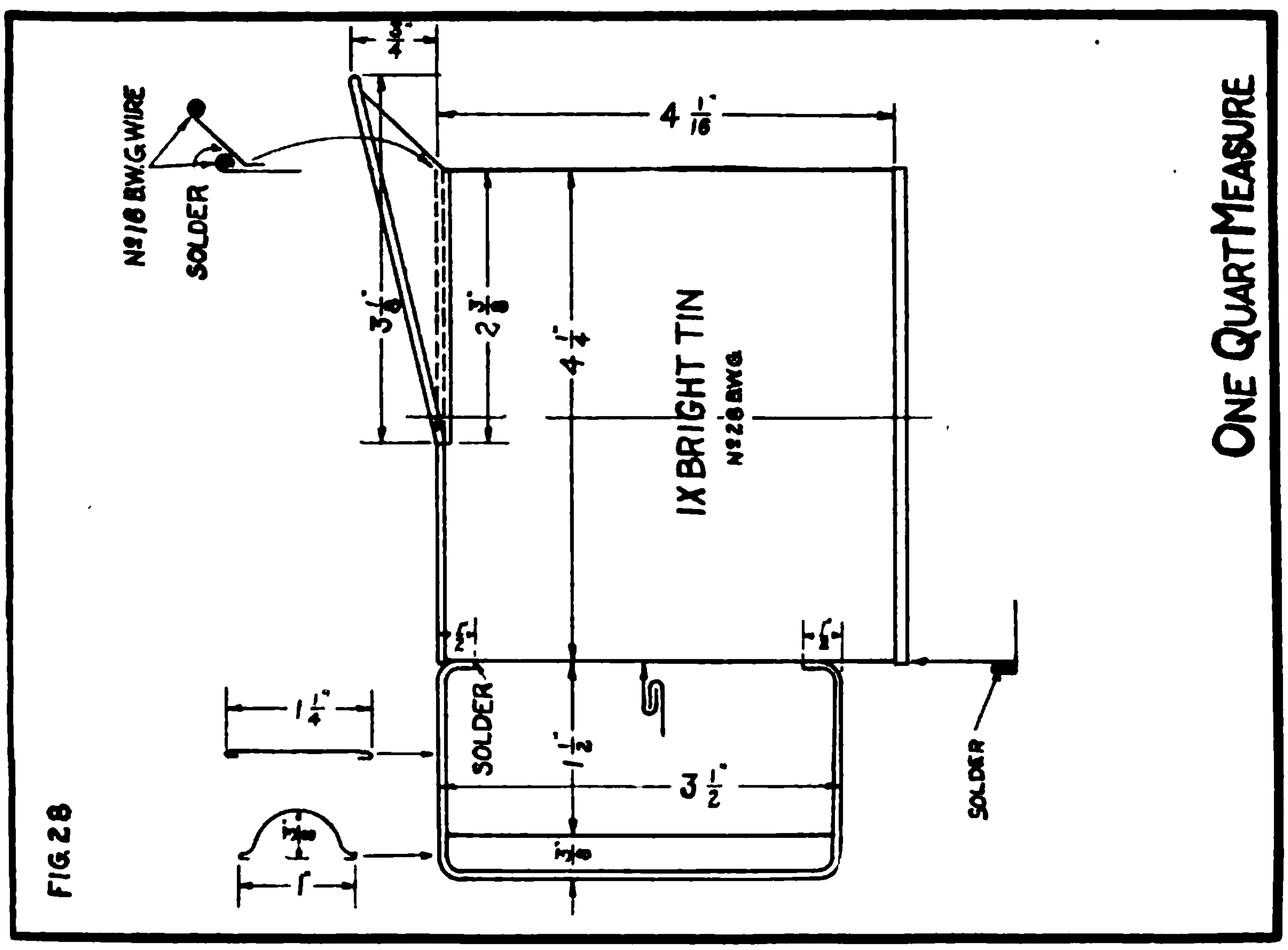
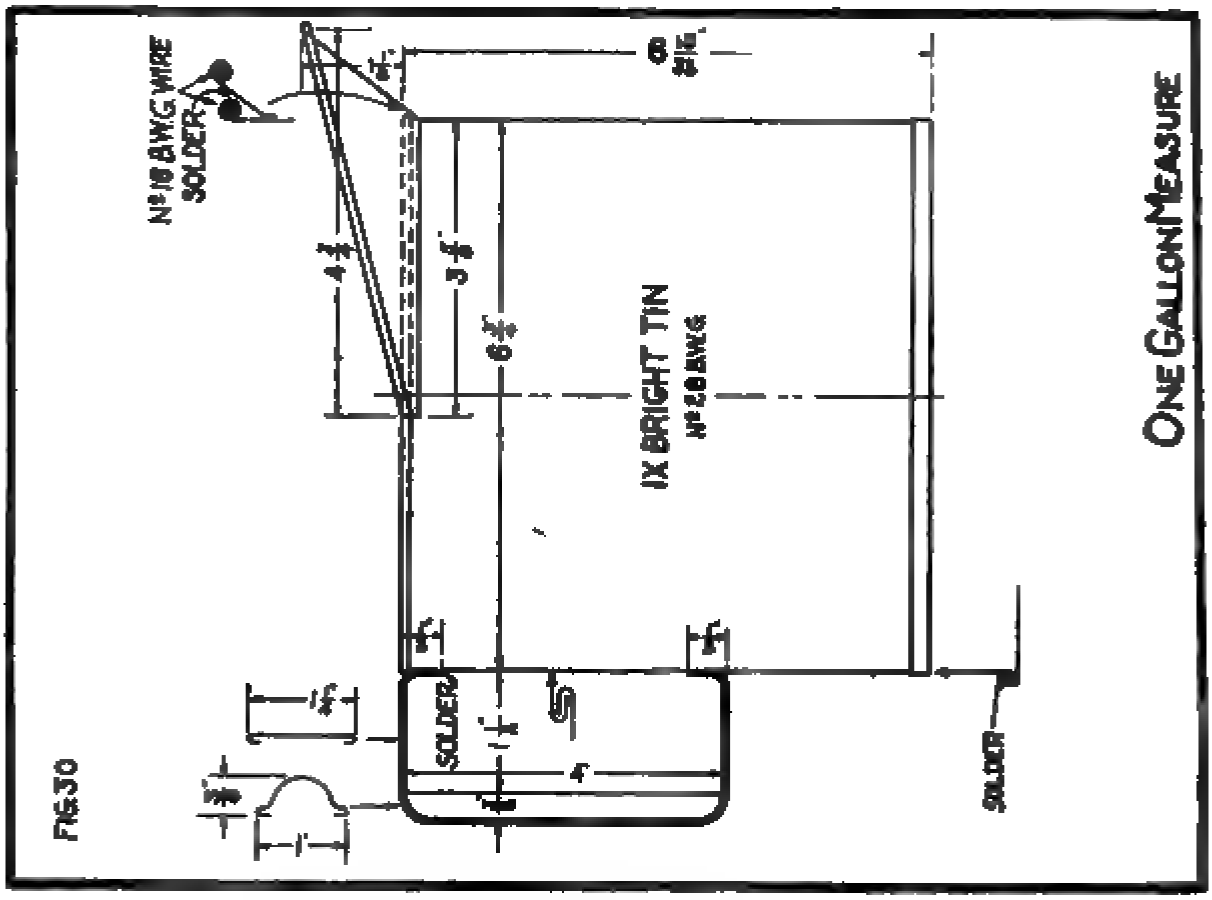


FIG. 28

ONE QUART MEASURE


ONE GALLON MEASURE
IX BRIGHT TIN
SOLDER
FIG.30

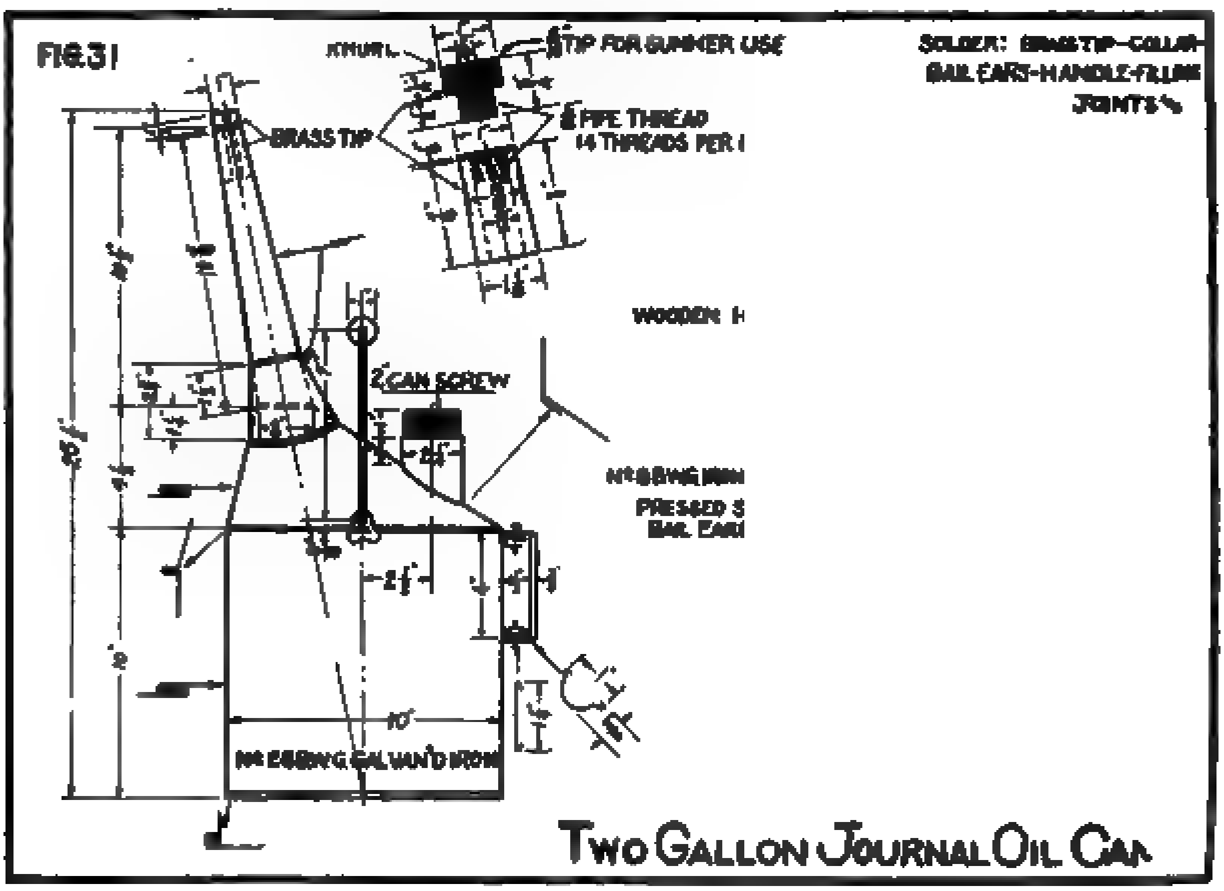
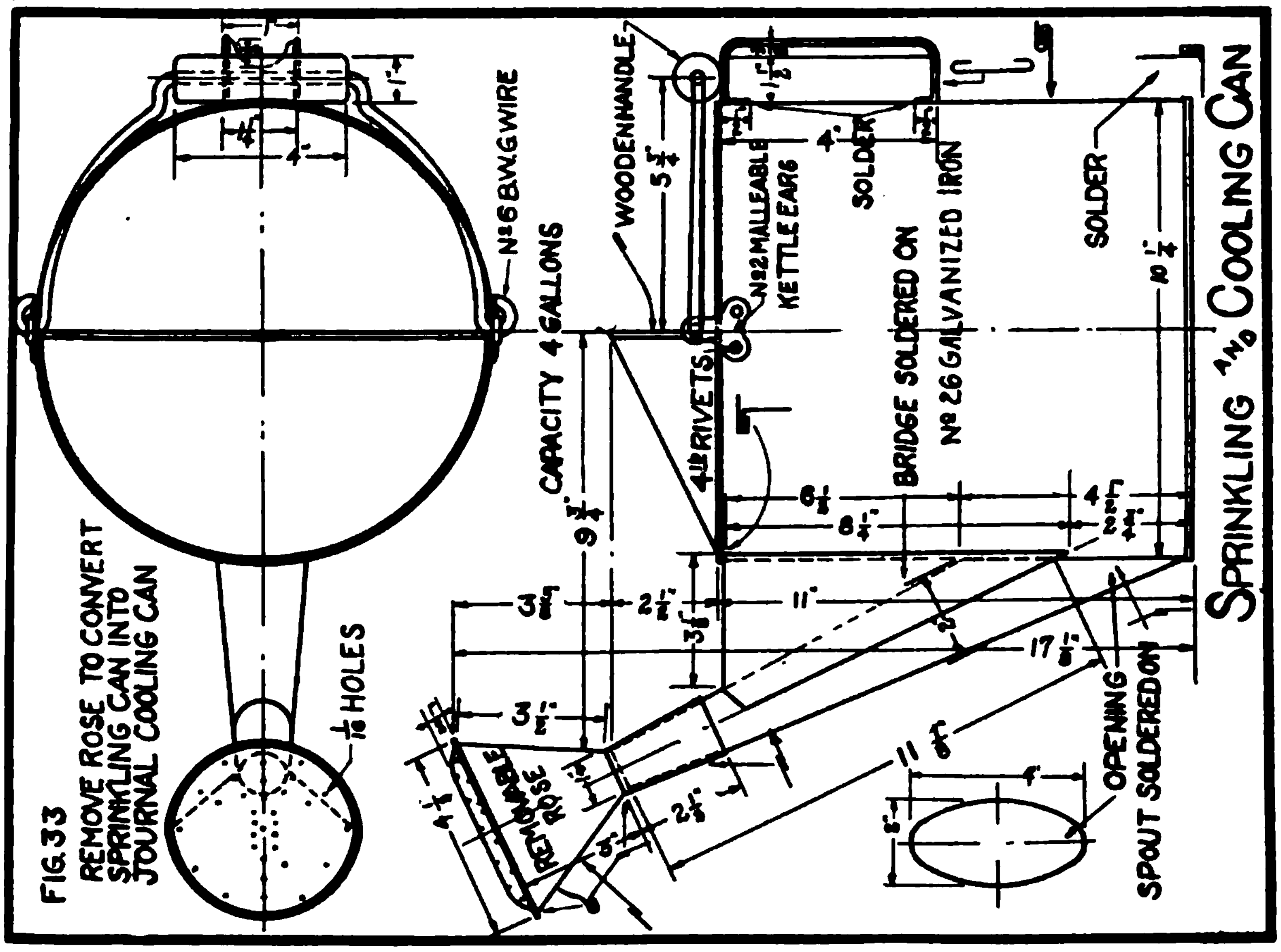
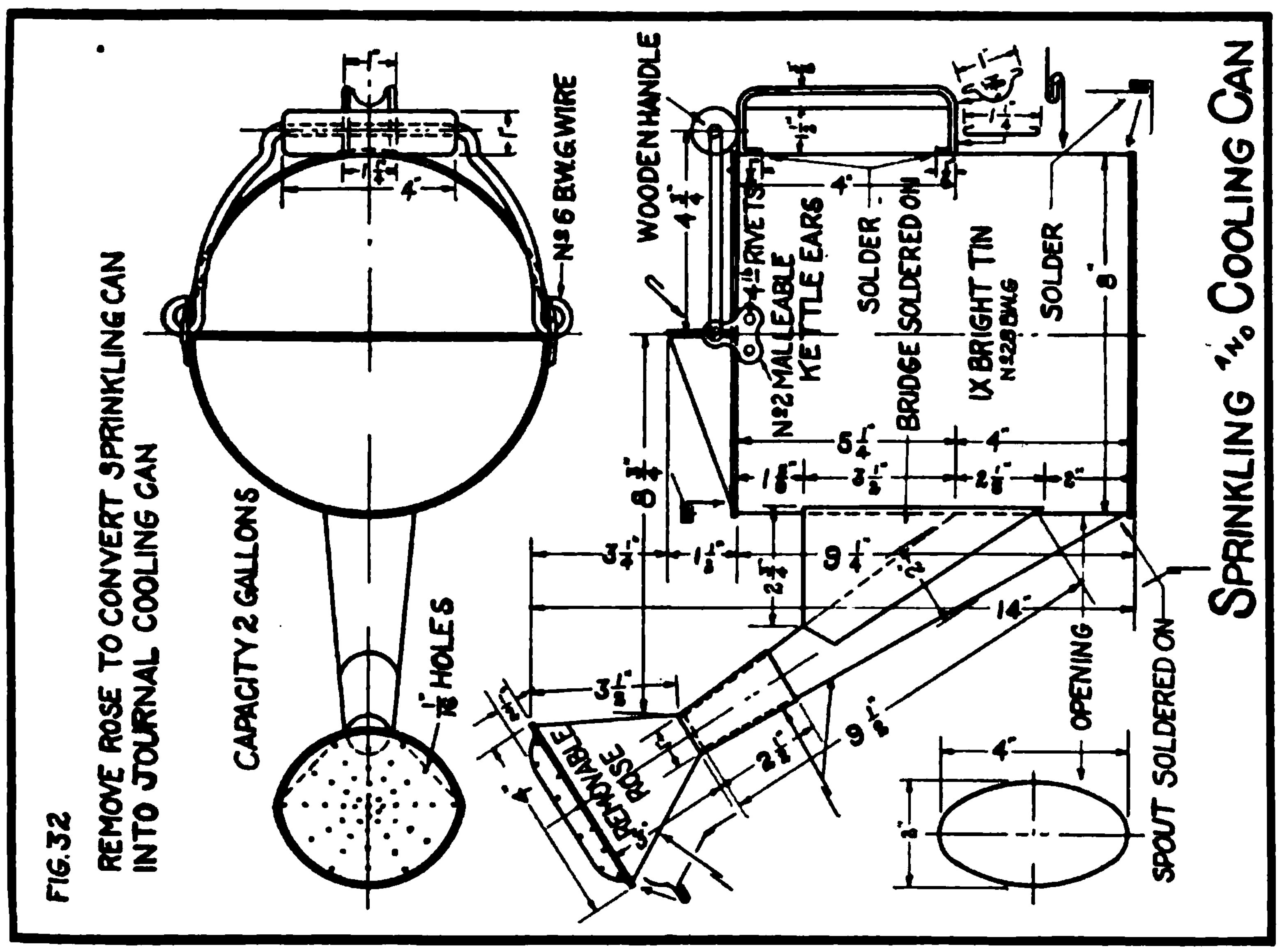


FIG.31
BRASS TIP
2" CAN SCREW
TWO GALLON JOURNAL OIL CAN


REMOVE ROSE TO CONVERT SPRINKLING CAN INTO JOURNAL COOLING CAN
1/16 HOLES
CAPACITY 4 GALLONS
WOODEN HANDLE
No 6 B.W.G. WIRE
No 2 MALLEABLE KETTLE EARS
4 1/2 RIVETS
SOLDER
BRIDGE SOLDERED ON
No 26 GALVANIZED IRON
REMOVABLE ROSE
OPENING
SPOUT SOLDERED ON
SPRINKLING AND COOLING CAN
FIG. 33


REMOVE ROSE TO CONVERT SPRINKLING CAN INTO JOURNAL COOLING CAN
CAPACITY 2 GALLONS
1/16 HOLES
No 6 B.W.G. WIRE
WOODEN HANDLE
4 1/2 RIVETS
No 2 MALLEABLE KETTLE EARS
SOLDER
BRIDGE SOLDERED ON
IX BRIGHT TIN No 28 B.W.G.
REMOVABLE ROSE
OPENING
SPOUT SOLDERED ON
SPRINKLING AND COOLING CAN
FIG. 32

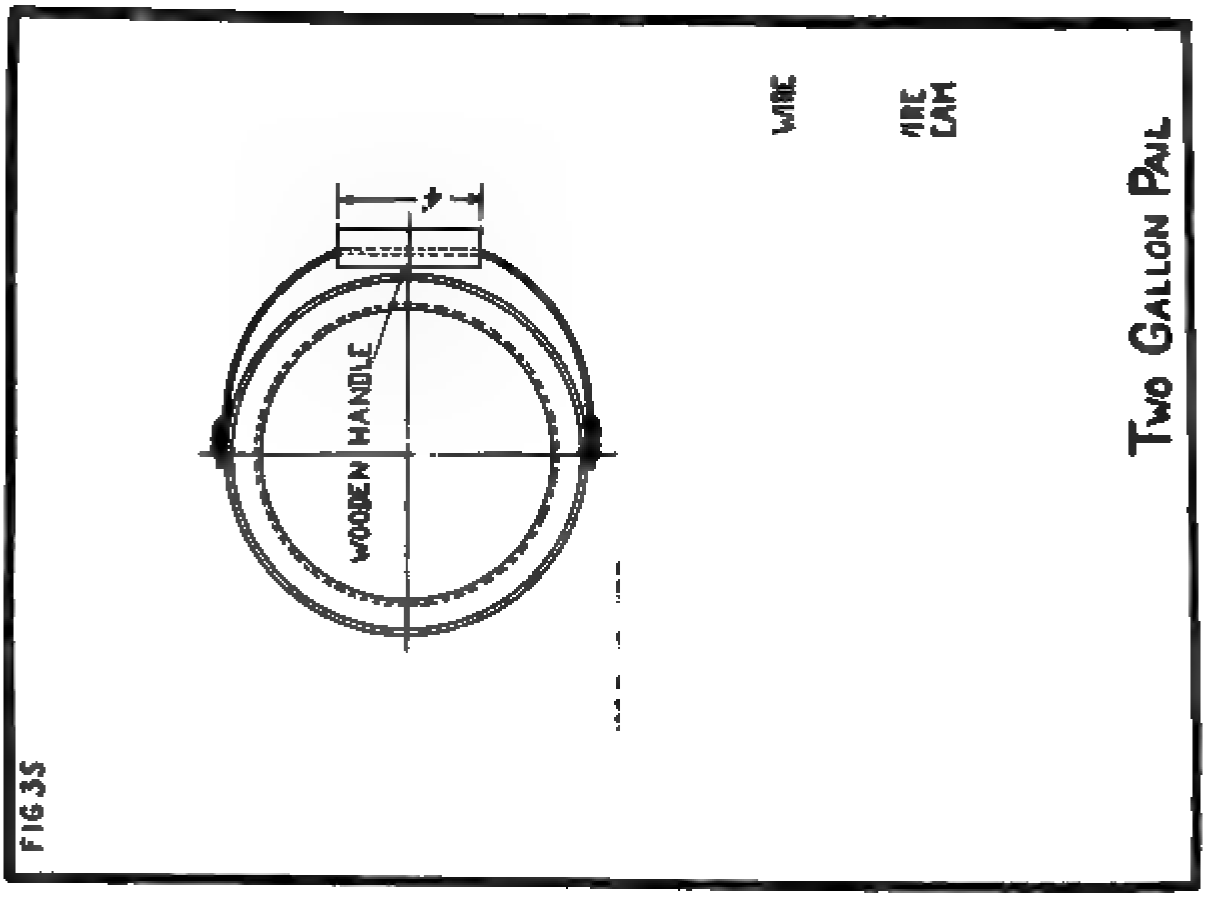


FIG 35

Two Gallon Pail

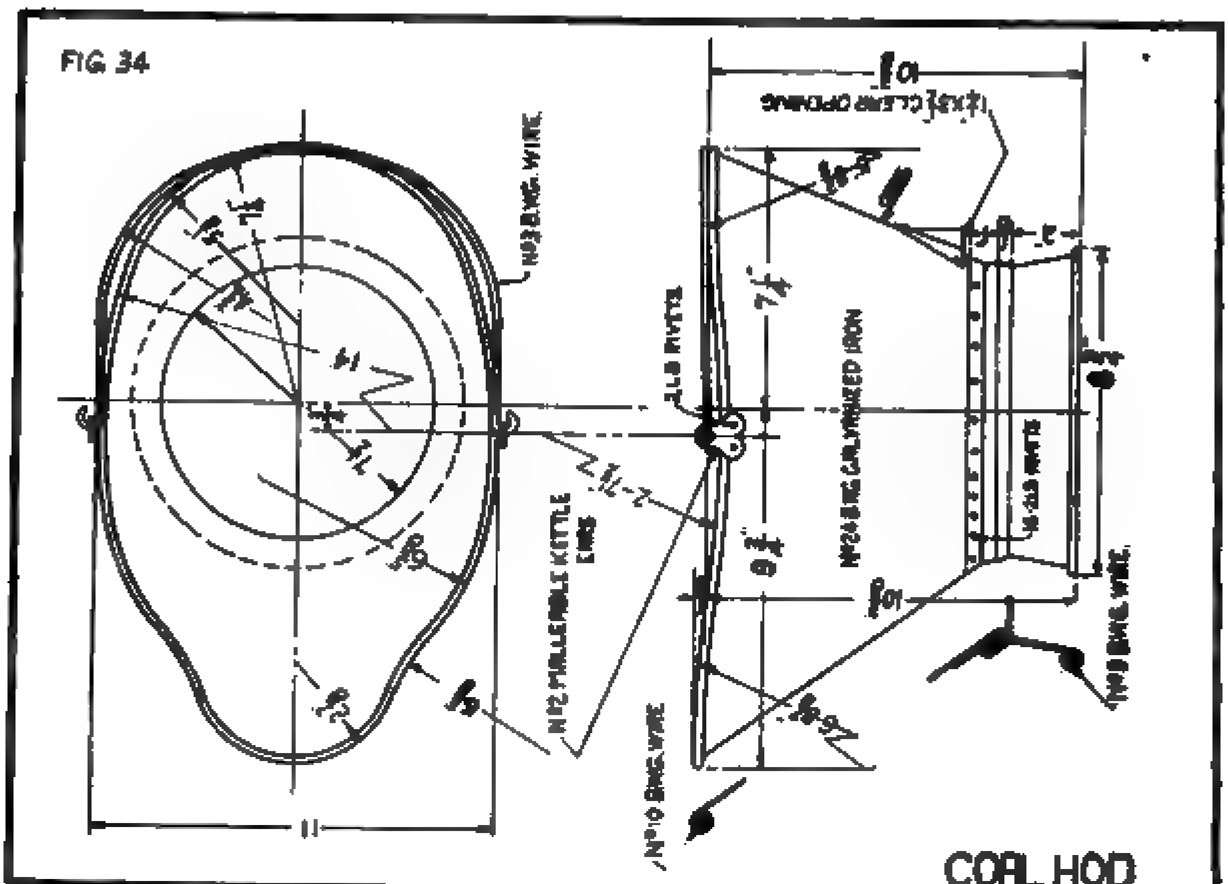


FIG. 34

COAL HOD

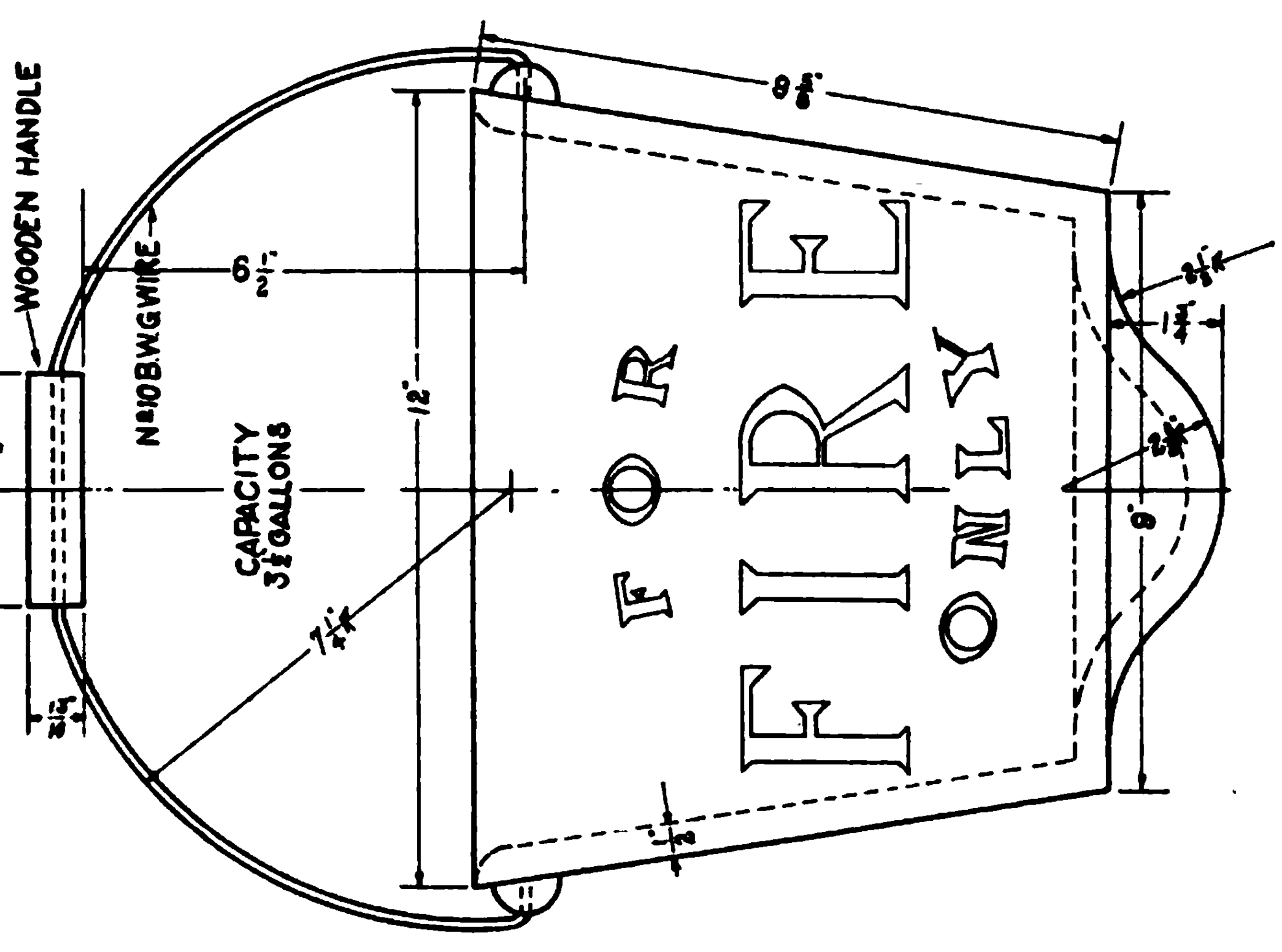


FIG. 37

FIBRE BUCKET

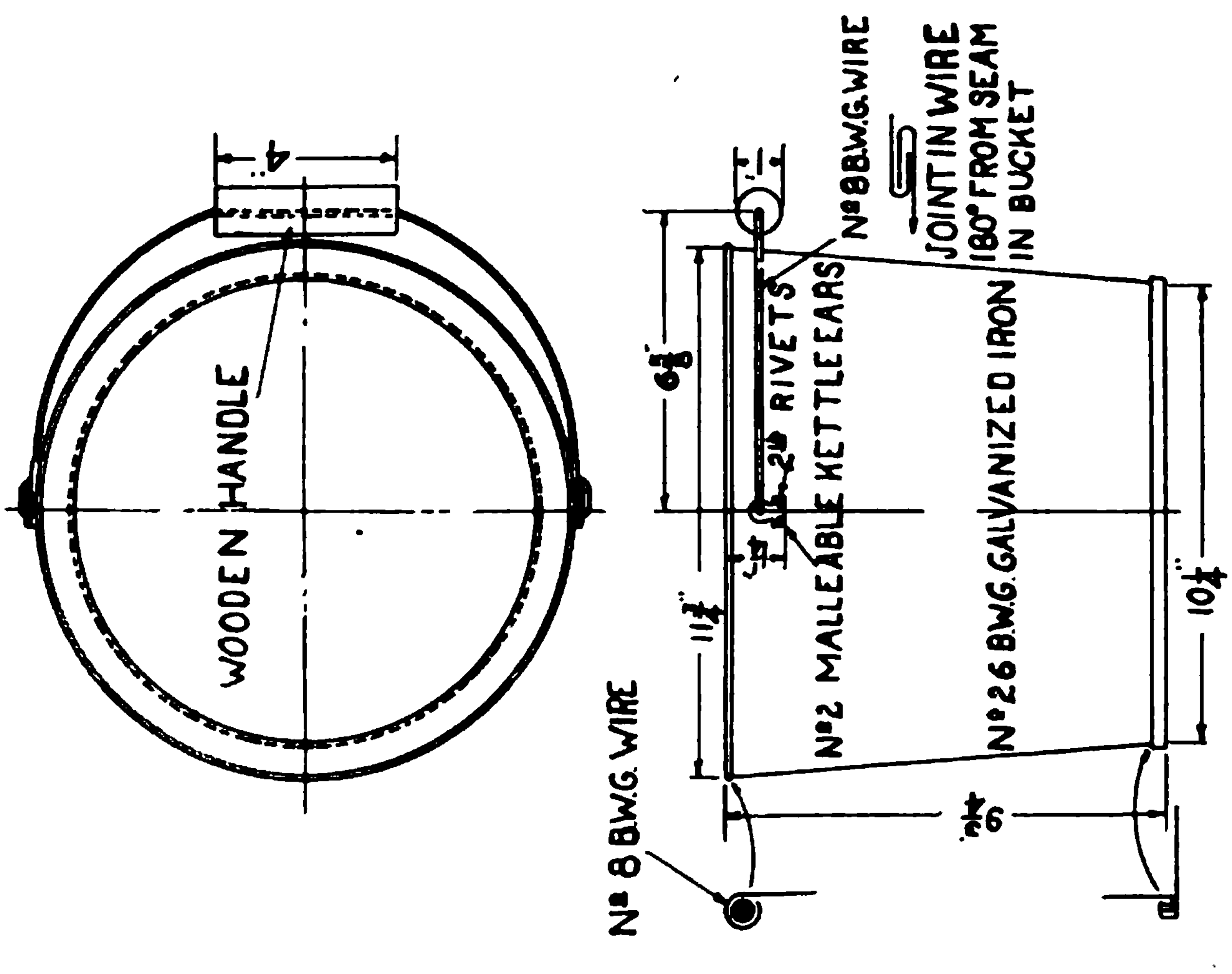


FIG. 36

FOUR GALLON PAIL

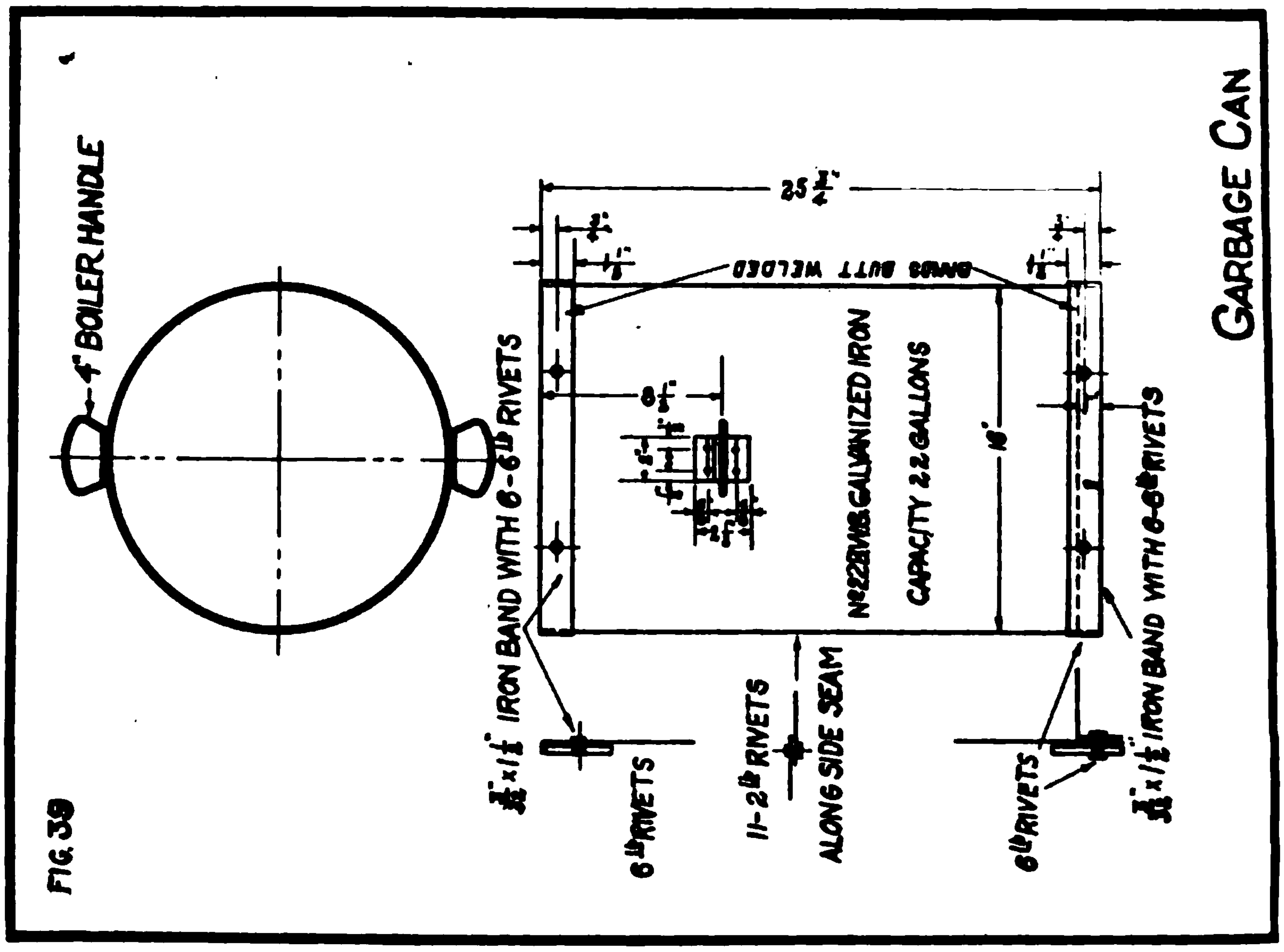


FIG. 39
4" BOILER HANDLE
25¾"
ENDS BUTT WELDED
$\frac{3}{16}$" x 1½" IRON BAND WITH 6-6 lb RIVETS
No 22 B.W.G. GALVANIZED IRON
CAPACITY 22 GALLONS
18"
11-2 lb RIVETS
ALONG SIDE SEAM
6 lb RIVETS
GARBAGE CAN

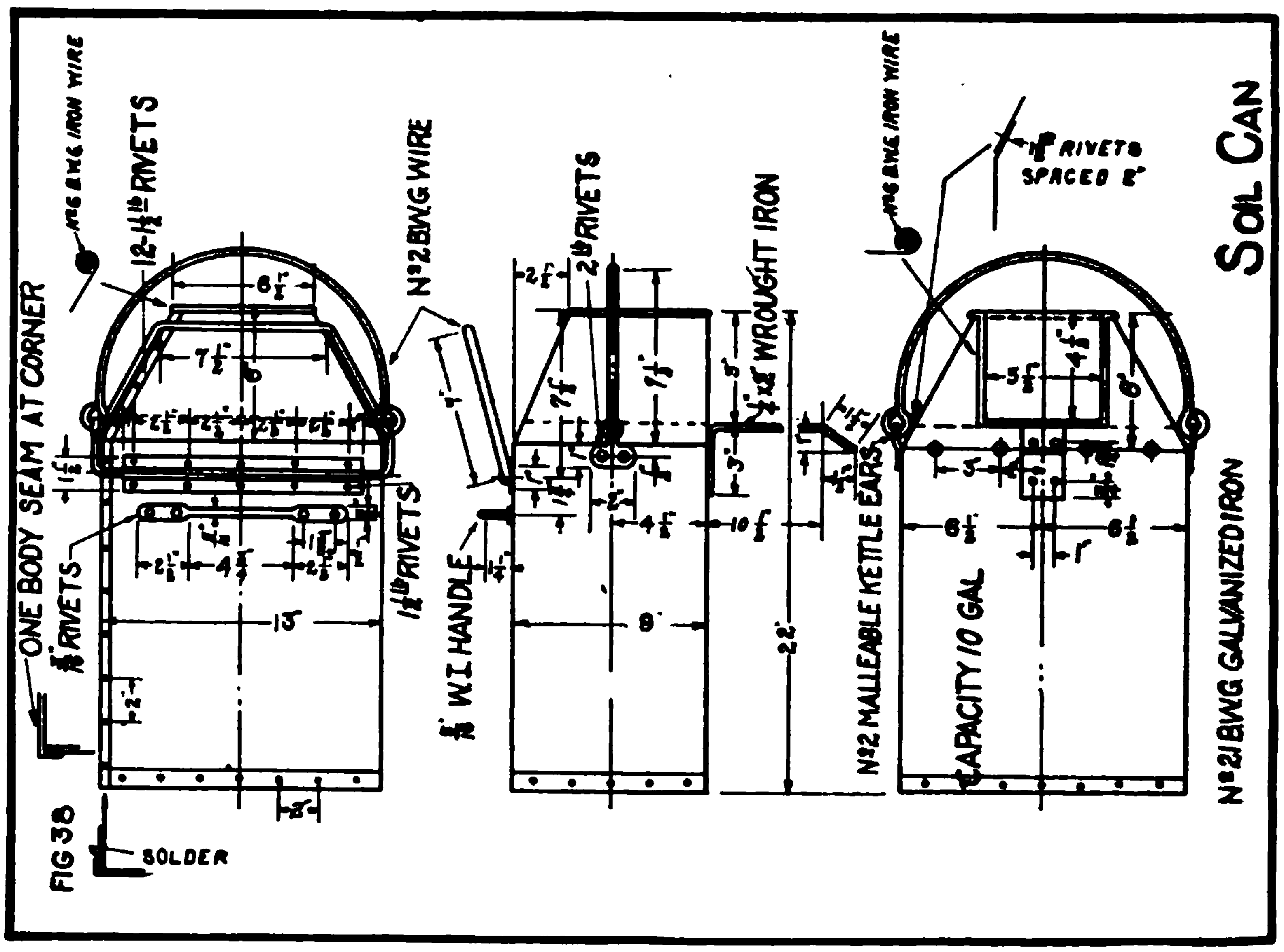
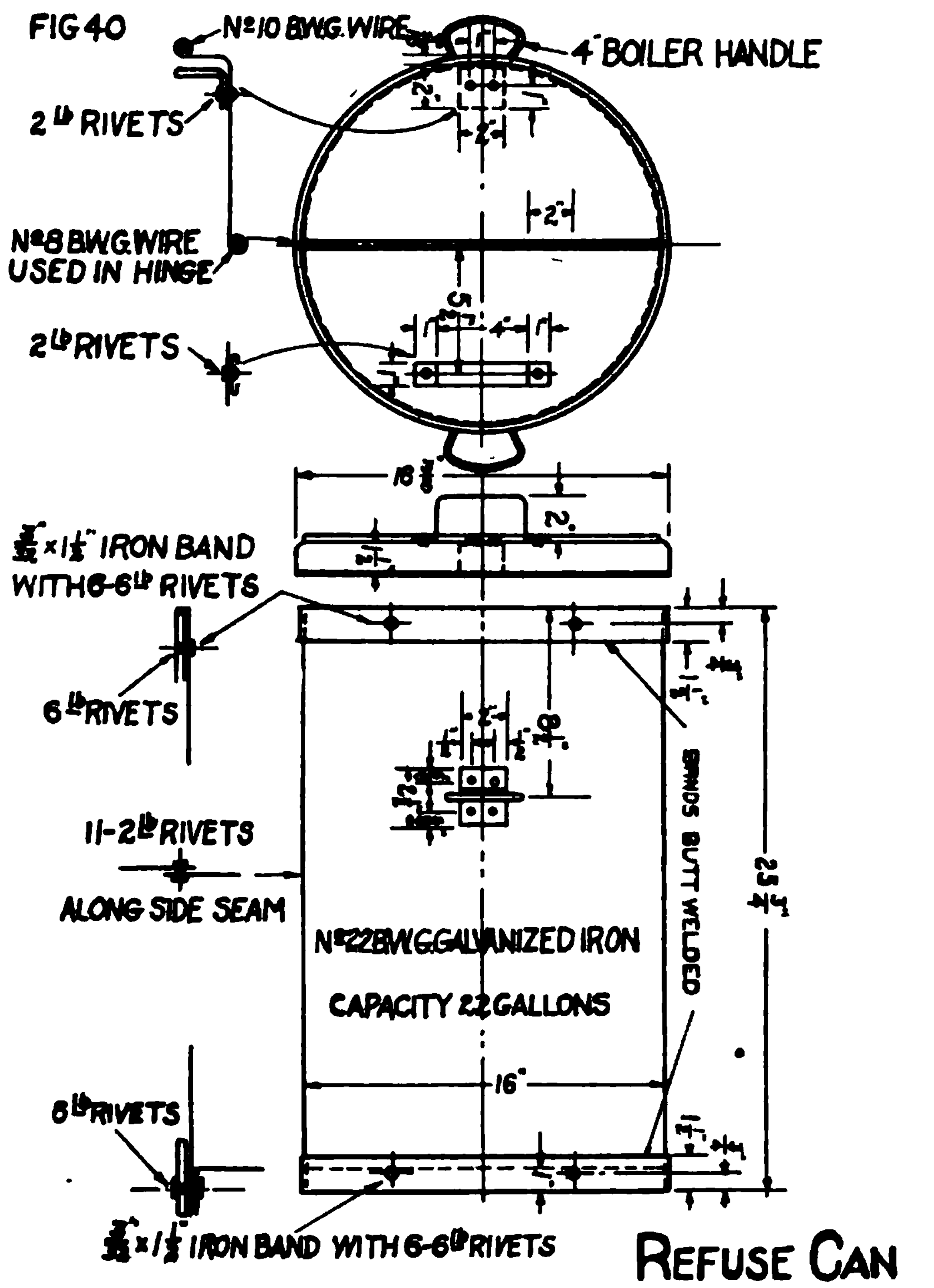


FIG 38
SOLDER
ONE BODY SEAM AT CORNER
$\frac{3}{16}$" RIVETS
No 6 B.W.G. IRON WIRE
12-1½ lb RIVETS
No 2 B.W.G. WIRE
1½ lb RIVETS
13"
$\frac{5}{8}$" W.I. HANDLE
2 lb RIVETS
¼" x 1½" WROUGHT IRON
22"
No 2 MALLEABLE KETTLE EARS
1½ lb RIVETS SPACED 2"
CAPACITY 10 GAL
No 21 B.W.G. GALVANIZED IRON
SOIL CAN

FIG 40



REFUSE CAN

In 1915 the following manual of instructions for enginemen and firemen which embodies all the essential points of efficient locomotive operation, and at the same time is brief and free from technical data, was adopted as Recommended Practice.

Introduction.

The object of these instructions is to bring about the economical use of fuel, to promote good practice in the operation of locomotives, and to improve the methods of firing.

As the engineman is in charge of the locomotive, his instructions must be followed, and both he and the fireman should work together to bring about the desired results. The best fireman can not make a good showing with an engineman who does not coöperate with him in the proper handling of the injector, throttle and reverse lever. The fireman is not alone responsible for the saving in coal, as a great deal depends on the engineman in his proper operation of the locomotive, and the latter should give instructions and suggestions to the fireman, based on his experience, to bring about the best results.

An efficient fireman is one having the skill and knowledge which enables him to make the fuel, supplied to the fire box, evaporate into steam as much water as possible, or, in other words, he makes the fuel perform its full duty. There are other qualities which increase the value of a fireman, but the ability to keep up steam is the first consideration. Good judgment is an aid to success in every calling, but it seems especially essential in a fireman.

Economy in the use of fuel is required, because the fuel used on locomotives is one of the largest items of expense to all railroads. As the greatest portion of the fuel passes through the fireman's hands, he can use it economically (depending on his ability, skill and good judgment, coupled with the coöperation of the engineman in handling the locomotive), or he can waste it through lack of knowledge or inattention to his duties. Furthermore, by burning no more coal than is absolutely necessary, the labor of firing is lightened, and by taking an intelligent interest in the condition and operation of the locomotive, the fireman is a very important factor in the saving of coal and water.

By explaining to the new fireman the reasons why certain methods should be pursued in handling his work to bring about the best results, and by directing attention, if necessary, to improper methods on the part of the experienced fireman who may not use good judgment, the operation of the locomotive can be handled to the best advantage and the greatest saving of fuel effected.

Bituminous and Anthracite Coal.

1. Bituminous coals are usually composed of about 60 per cent carbon, 30 per cent gaseous or volatile matter, which burns as flame, and 10 per cent earthy matter, which remains on the grates as ash or clinker. Good anthracite coal contains about 85 per cent carbon, 5 per cent of gaseous or volatile, and 10 per cent earthy matter.

2. The burning of coal in a locomotive requires air, which must be admitted through the ash pan, grates and fire door. Smoke means imperfect combustion and waste of coal, and must be avoided as far as possible.

3. When bituminous coal is applied to the fire, the volatile or gaseous matter is expelled, and, if properly mixed with air and heated to a sufficient temperature in the fire box, the mixture will ignite, be consumed and pass from the fire box through the tubes and stack as a colorless vapor, leaving the solid matter on the grates in the form of coke, which burns more slowly. If, however, the gases are unconsumed, they will produce smoke.

4. Anthracite coal burns more slowly than bituminous, and, consequently, a larger grate area has to be provided in order that sufficient coal may be burned to give the required amount of steam. In other words, means must be provided to make a hard-coal burning locomotive of given proportions consume as much coal per hour as a bituminous burner of the same proportions; and no better way has been found than by designing this kind of a locomotive with a large fire box and a liberal grate area. Anthracite coal has to be fired to suit the size of the lumps used. If the coal is in large lumps, a heavy fire must be carried, because the lumps lie so open that the air would pass too freely through the fire if it were light. The smaller the size of the coal the thinner the fire can be. The fire should be started considerably in advance of leaving time from the engine-house, in order that a good fire will be on the grates when the start is made with the train.

5. The method of light and level firing, outlined in the instructions which follow, applies to firing both bituminous and anthracite coal.

Inspection of the Locomotive.

6. The engineman and fireman should be on hand in ample time before departure from the engine-house, to thoroughly inspect and lubricate the locomotive, in order to make sure that it is in proper condition and fully equipped for making the run. Any matters which, in the judgment of the engineman, should receive attention before departure, must be promptly reported. The fire, grates and ash pan, as well as flue sheet, must be examined, to see that they are in suitable condition for making the run. The condition of the fire should be such that it will make steam freely from the start. The shaker rigging should be operated to see that it is in good working order. The damper rigging (where provided) should also be

operated, to make sure of its condition. The ash pan and rigging should be examined, to see that the doors or slides are properly secured and in a condition to prevent hot coals dropping along the road, which are liable to start fires.

7. When locomotives are equipped with mechanically operated fire doors, grate shakers, or coal pushers, the same should be known to be in good working order before starting.

Preparation of the Fire.

8. When applying fuel in building up the fire, preparatory to starting, the blower should be used, to create the necessary draft, and the fire door should not be entirely closed between the shovelfuls of coal, but in all cases should be placed on or against the latch until the gases have been consumed, and the closing of the door will not result in the emission of heavy black smoke.

9. It is important that the grates should be clean and free from dead ashes and clinker. They should be left in a level position and secured there after each shaking, to prevent the fingers or edges of the bars being burned off. See that the foundation for a good fire is on the grates, that the fire is evenly distributed over the entire grate surface, and that the ash pan is clean. If these precautions are taken, the fire will be in condition to maintain the steam pressure during the trip.

Taking Coal and Water.

10. After taking coal at coaling stations, the coal pile should be trimmed, to insure the coal from falling off tenders while in transit, which saves coal and eliminates a danger to passing trains, trackmen, etc.

11. Coal or water must not be taken more frequently than is necessary, as it requires extra coal to again bring the train up to speed, especially if on a grade. This is a matter requiring good judgment, as it would not do to run short of coal or water before reaching the next coal chute or water tank. Where possible, take water only from tanks containing good water, and as little as possible from those containing bad water.

Making the Start.

12. The boiler must not be filled too full of water as soon as the locomotive leaves the engine-house. Leave a space so that the injector can be worked to prevent popping.

13. The lubricator should be started about fifteen minutes before leaving the terminal, and should be set to feed regularly, in order to insure lubrication of valves and cylinders at the start of the trip. Proper lubri-

cation of the valves, cylinders and machinery helps to save fuel by reducing friction.

14. The sprinkler hose must be used frequently to keep down dust on the foot-plate and in the cab, and to wet the coal in the tender. The use of too much water on the coal should be avoided, as it has to be evaporated by the fire, and may result in the flues stopping up.

15. Care should be taken in starting train to prevent damage to draft gear and couplers. Preventing delays saves coal, and preventing damage saves repair costs.

16. Slipping of the drivers should be guarded against, as the heavy exhaust tears and upsets the fire and fuel is wasted in rebuilding it. Furthermore, slipping wears out tires and rails, and may damage the running gear.

Method of Firing.

17. A hard and fast rule covering the depth of fire at the start can not be made. Good judgment must be used, as the conditions under which the start is made, such as grade, weight of train, speed, etc., will influence to a great extent the kind of fire that is on the grates.

18. Large lumps of coal do not make a satisfactory fire, and they should be broken into pieces not larger than 3 in.

19. Always fire as light and level as possible consistent with the steam requirements, scattering the coal over parts where the bed is thinnest and the fire brightest, in order to prevent it from becoming dead in spots. Large quantities of coal placed in the fire box at one time cool down the fire, cause smoke and waste of coal; small quantities at regular intervals will keep the fire bright, reduce smoke and take less coal to keep up steam pressure, resulting in a reduction in the work of firing.

20. Very heavy firing is apt to cause leaks, and may cause fire-box sheets to crack, as the air can not pass readily through a heavy fire, and large quantities of cold air will be drawn through the fire door and the thinnest places in the fire, resulting in chilling the flues and sheets, the formation of smoke and a reduction in steam pressure.

21. The fire door should be placed on the latch, as far as possible, between each shovelful of coal, to keep down the smoke by increasing the admission of air through the door.

22. Do not put four or five shovelfuls of coal into the fire box at one time. One, or perhaps two, will give better results, and if more than one shovelful is used at one firing, they should not be put into the same spot. Fig. 1 shows how coal should be introduced into a simple, and Fig. 2 a double door fire box, each successive shovelful being thrown to the points indicated by the numbers. This method of firing will tend to make the bed of fire uniform; but, of course, the judgment of the fireman must be depended upon to see that thin spots are kept covered.

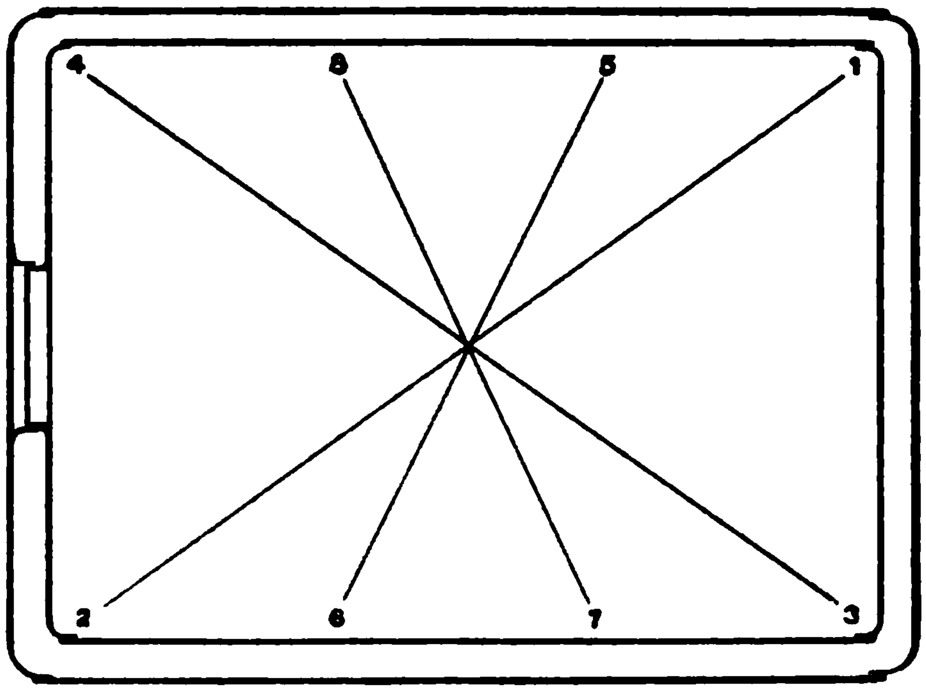


FIG. I.

FIGURE NO. 2 SHOWS THE METHOD OF CROSSFIRING A WOOTEN FIREBOX AS INDICATED BY SUCCESSIVE NUMBERS ON THE ARROWS, FIRST FIRING ON THE ONE SIDE AND THEN THE OTHER, ALONG THE WALLS AND CENTER OF THE FIREBOX.

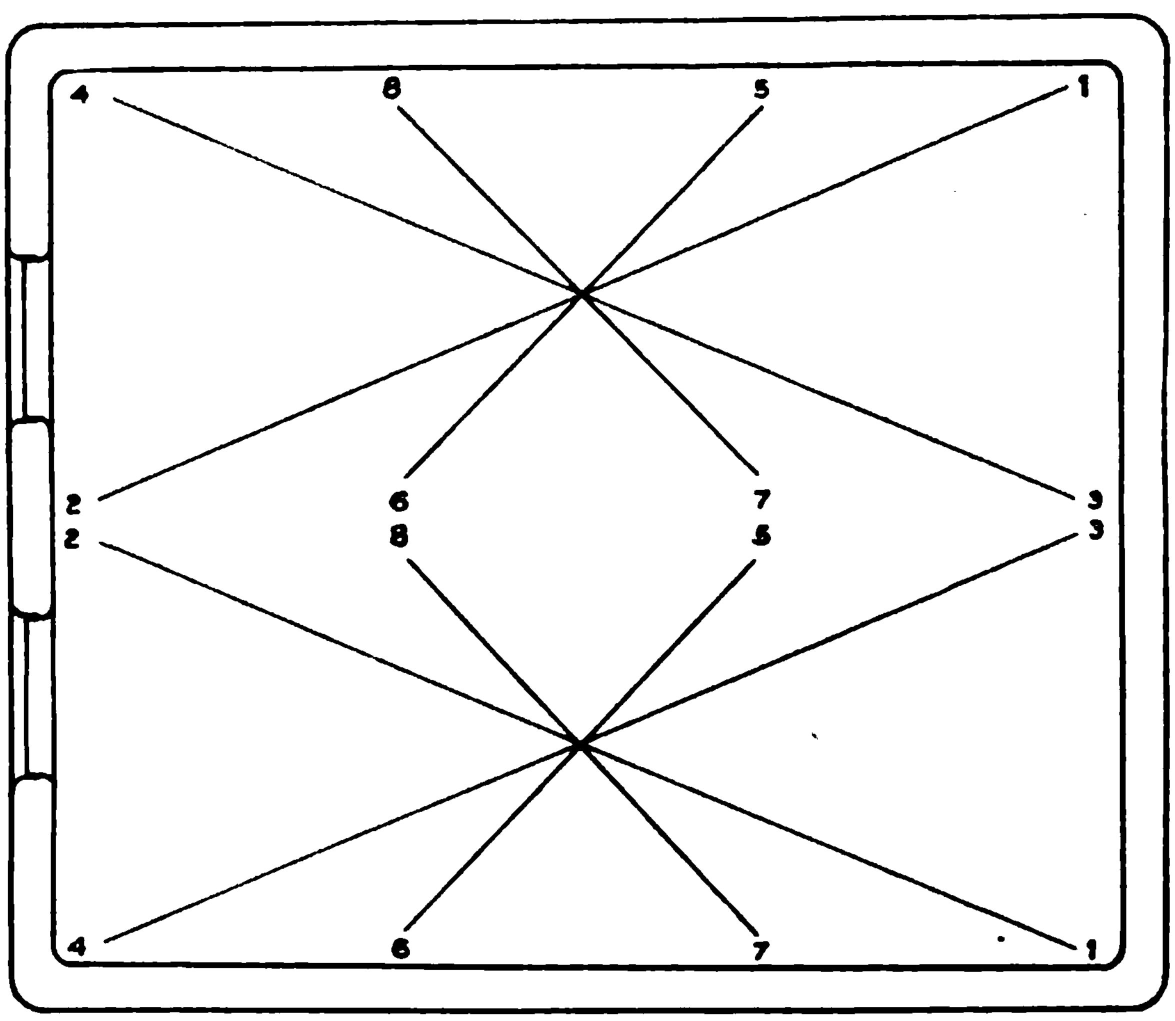


FIG. 2.

23. Fig. 3 illustrates the effect of heavy firing under the door, which lowers the temperature at that part of the fire box, since the heavy bed of coal does not allow sufficient air to pass through it to supply oxygen for proper combustion, and smoke is liable to result on account of part of the fuel gases passing away unconsumed.

24. Figs. 4 and 5 show the condition of the fire when the practice of light and level cross-firing, illustrated by Fig. 1, is followed. The bed of fuel is slightly heavier next to the sheets than on other parts of the grates. This is good practice, because there is a tendency for more air to pass up beside the sheets, which would cause thin spots to form around the edges, allowing cold air to pass up into the fire box. Maintaining a slightly thicker fire along the edges prevents this trouble.

25. Fig. 6 shows the thinning action of the draft around the edges.

26. Fig. 7 shows the effect of a temporary reduction in fire-box temperature when a shovelful of coal is introduced.

27. Fig. 8 shows the restoration of temperature before the second shovelful is introduced at another part of the fire box, as is the case in the system of light and level cross-firing.

28. Fig. 9 shows the effect of a spot or hole in the fire. The admission of a large volume of cold air through such spots causes a serious chilling effect.

29. Fig. 10 shows the application of a brick arch and the path of the products of combustion from the fire to the flues.

Operation of the Locomotive.

30. When the throttle is closed, before making a stop or for drifting, the blower must be used and the fire door placed on latch, and dampers (where provided) should be closed, in order to check the fire and prevent steam from blowing off. This practice, with the exception of the use of the blower, should be followed after using the scraper or slash bar, and when on sidings, in yards or at terminals.

31. Firing should be stopped long enough before steam is shut off to prevent smoke and waste of coal, and when making station stops the fire should be in such a condition that more coal need not be added until after the start is made. It is bad practice to begin firing as soon as the throttle is opened, because the deadening effect of the fresh coal, together with the use of large quantities of steam, will cause a reduction of steam pressure. If firing is necessary at this time, it is better to do it while standing.

32. The grates should be shaken only when necessary to clear the fire of ash and clinker in order to admit sufficient air for proper combustion, and in such a manner as to avoid the loss of good fires, which means waste of fuel. Care should be taken after each operation to place the grates in a level position, to avoid burning the fingers, which is liable

FIG. 3.

FIG. 4.

FIG. 5.

FIG. 6.

Fig. 7.

Fig. 8.

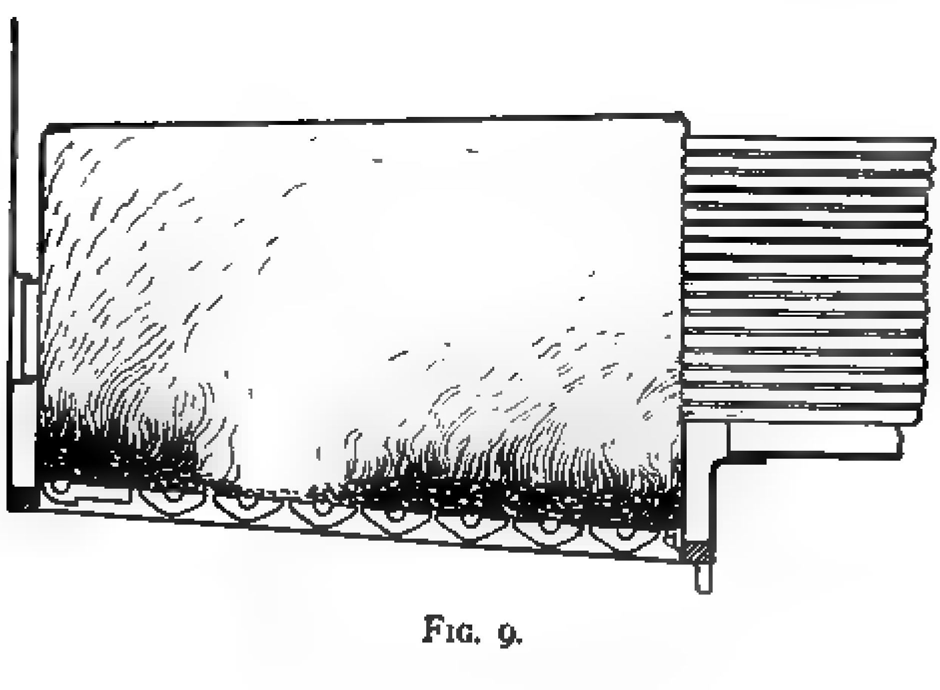


Fig. 9.

Fig. 10.

to occur if the grates are allowed to remain at an angle with the fingers projecting into the fire.

33. The waste of steam through safety valves must be avoided. Frequent blowing off of safety valves shows poor judgment, and implies that economy is not being practiced. Tests have demonstrated that about 15 lb. of coal, or one shovelful, are required to supply the steam blown off in one minute, or, in other words, if the safety valves are open for 133 min., about one ton of coal is wasted.

34. Careful attention must be given to the use of the injector and the height of the water level in the boiler. The proper handling of the injector is a very important matter in fuel economy. The best fireman can not make a showing if the engineman floods the boiler. If the injector is to be used to prevent popping, a space must be left so that the injector can be worked. The injector should be put on before, and not after, the safety valve opens. The blower should also be reduced or shut off before the steam pressure rises to the blowing-off point

35. Coal can be saved by the proper use of the injector in feeding the locomotive regularly at a rate governed by the demands, and by taking advantage of every opportunity to increase the height of the water level when not working the locomotive to full capacity, for example, while drifting, standing in stations or switching, and permitting the level to drop slightly between stations or on hard pulls

36. It is bad practice to start out, after making a stop, with the injectors working. The cool water introduced into the boiler while the throttle was closed starts circulating and reduces the steam pressure. If a start is made under these conditions, the steam pressure will be still

further lowered and an excessive amount of firing necessitated. It is, therefore, preferable to start the injector after a train is well under way.

37. Be sure that the crown sheet is thoroughly covered with water. When ascending a grade see that the water is carried high enough so that when the locomotive reaches the top of the grade and passes on to a lower grade or a down grade, the crown sheet will be well covered.

38. The water level must never be high enough to allow water or very moist steam to be carried over the valve chambers and cylinders, because it will destroy the lubrication of these parts, and may result in serious damage, due to knocking out cylinder heads, breaking pistons or bending of main rods.

39. The engineman can save coal and greatly assist the fireman in his work by handling the throttle and reverse lever in such a manner that the minimum amount of steam will be used. The locomotive should be operated with a full throttle opening (except when starting or drifting) when the cut-off is 25 per cent of the stroke, or greater; but if 25 per cent cut-off with full throttle gives more power or speed than is needed, the reverse lever should be left at 25 per cent cut-off and the throttle partly closed as necessary. With locomotives using superheated steam it is well to use 15 per cent cut-off instead of 25 per cent, as mentioned above.

Condition of Fire Reaching Terminal.

40. Locomotives should not be brought into terminals with a dead fire, which is liable to cause the flues to leak, nor with too heavy a fire, which will cause a waste of coal when the fire is cleaned.

Cleaning Fires.

41. When banking or cleaning fires, the blower should be used as little as possible, to avoid the rapid cooling down of the fire box and flues, which may cause leaks.

42. When cleaning fires, or with a banked fire, the excessive use of the injectors must be avoided, as this will result in injury to the flues, by the rapid reduction of the temperature of the water in the boiler producing contraction, without sufficient fire in the fire box to counteract this effect.

43. After the fire has been cleaned of ash and clinker, the clean fire must be placed at the front end of the grates (where brick arches are not used), and maintained in good condition by applying small quantities of fuel as may be required, in order to prevent cold air from passing through the front end of grate and injuring the flues. Where brick arches are used, the fire can be banked further back, as the hot arch brick protect the flues.

Final Inspection and Work Reports.

44. Great care should be exercised on the part of the engineman, on reaching the terminal, to make a thorough examination of the locomotive,

and prepare an intelligent written report for the information of the engine-house foreman and those who make repairs.

45. Leaky piston and valve-stem packing, cylinder packing, or valves which cause blowing, all tend to draw on the coal pile unnecessarily, as it takes coal to generate wasted steam. This also applies to locomotive steam-heat appliances, cylinder cocks, safety valves which blow down too much steam pressure before closing, or, in other words, to all steam wasted.

46. The fireman should be consulted in regard to any defects that have come to his notice, especially with the grates, grate rigging, brick arches, ash pan, firing tools, scoop rigging and dampers (where provided). Particular attention should be given to the condition of the brick arch, because this device, properly maintained, is a considerable factor in the saving of fuel and the reduction of smoke.

47. It is important that the engineman, as well as the locomotive inspectors, report all defects in a locomotive, on arrival at a terminal, which require attention before the locomotive is again placed in service, especially as some defects can be detected to the best advantage while the locomotive is in service.

Special Instructions for the Operation of Superheater Locomotives.

48. The general operation of superheater locomotives is the same as the ordinary saturated steam locomotive. Attention is directed to a few items in connection with superheater locomotives which need careful consideration.

49. Cylinder cocks should be kept open when standing, and, as far as possible, when starting, until dry steam appears.

50. A hydrostatic lubricator should be started at least fifteen minutes before leaving time, in order that the valves and cylinders may be thoroughly lubricated when starting on the trip. The oil supply to the cylinders should be constant, as there is no water in the steam to assist in the lubrication, and, on this account, the superheater locomotive requires more careful lubrication for valves and cylinders than the saturated steam locomotive.

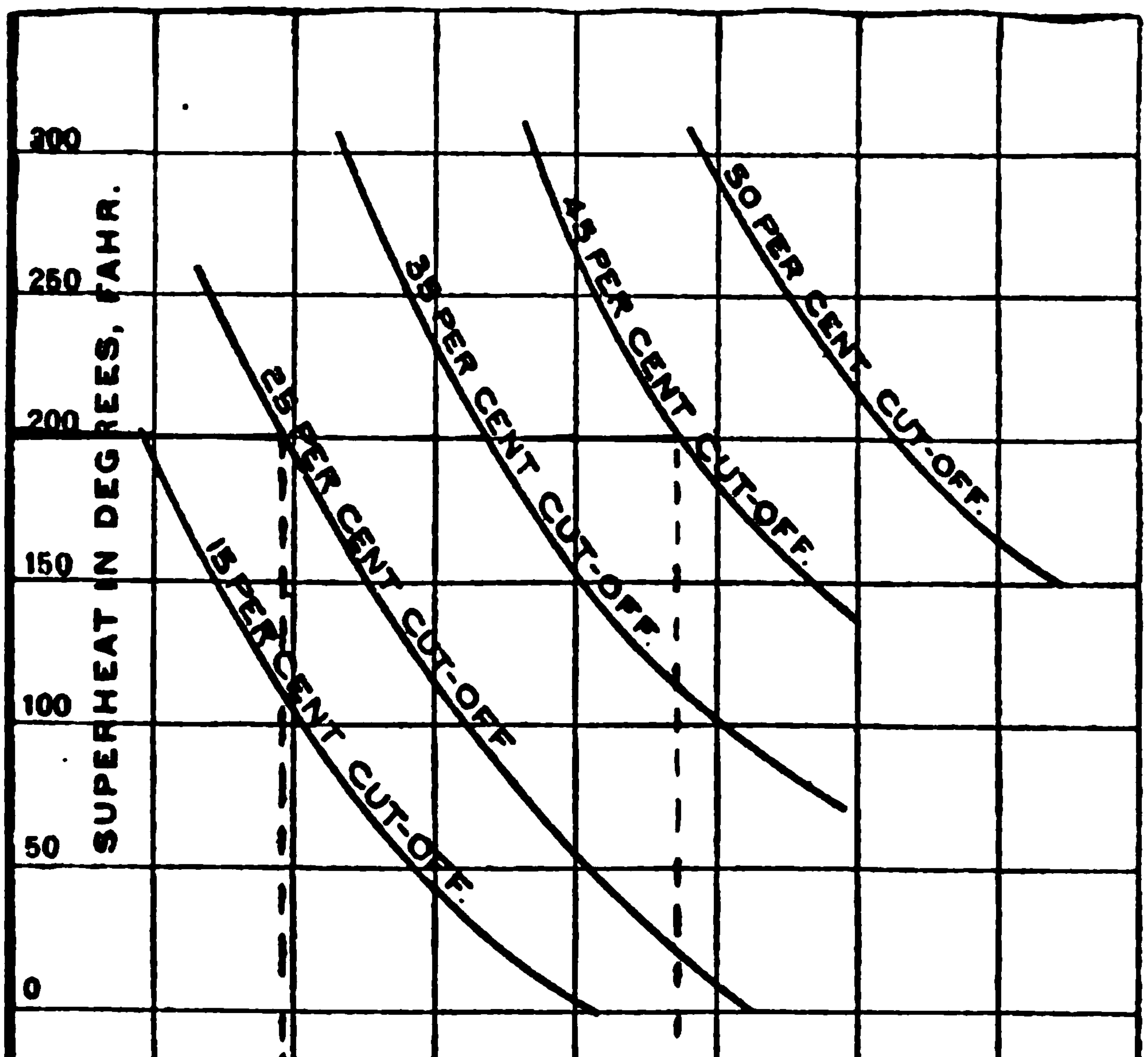
51. In starting, the reverse lever should be in full gear, to insure oil distribution to the full length of the valve bushings. Care must be taken that the water level in the boiler is not sufficiently high to cause water to carry over into the superheater, thus washing off the lubricant from the valves and cylinders.

52. Special attention must be given to the handling of the injectors, in order to prevent carrying too high a water level in the boiler. If water is carried over into the superheater while the locomotive is in operation, it will have to be evaporated in the superheater, causing a partial or total loss of superheat and decreasing the efficiency of the locomotive. Handling the water properly saves coal for the company and makes the fireman's work easier.

53. A superheater locomotive should not be moved without the required air pressure and the brakes in operative condition. When water is carried over into the superheater, part or all of it will flash into steam, even after the throttle is closed. Under the above condition the locomotive is not under control, because the valve chamber is filled with steam.

54. Superheater locomotives should be operated with a full throttle opening and reverse-lever control, as far as service conditions will permit, the exceptions being: When starting a train, when using a very small quantity of steam, and when drifting. (See paragraph 39.) The chart shown illustrates the point in question, and shows the variation in coal consumption with various degrees of superheat for each of the following

Variation in Coal Consumption with Varying Superheat at Different Cut-offs.



cut-offs: Fifteen per cent, 25 per cent, 35 per cent, 45 per cent and 50 per cent. The figures were taken from tests of a large Pacific type locomotive, but they apply with equal force to all superheater locomotives. For example, take the curve for 25 per cent cut-off at 200 deg. of superheat. The coal consumption is about 2 lb. per indicated h-p. hour. Then take the curve for 45 per cent cut-off at 200 deg. of superheat. The coal con-

sumption is about 3.3 lb. per indicated h-p. hour. This clearly shows why it is better to operate with a full throttle and reverse-lever control rather than with a partial throttle and long cut-offs. The difference for the example taken is 1.3 lb., or 39 per cent over the incorrect method. The chart also shows the advantages of a high degree of superheat at any cut-off in reducing the coal consumption per indicated h-p. hour.

55. It is advisable, in order to avoid the suction of hot gases from the smoke box into the steam chest and cylinders, to keep the throttle slightly open when drifting or making stops, as by passing a very slight amount of steam through the cylinders, the front-end gases can not be drawn into the exhaust column. The throttle must be completely closed just before coming to a full stop.

56. The firing should be light and regular, to produce as high flame temperature and as perfect combustion as possible in the fire box. A high fire-box temperature results in high superheat, which will be obtained by a small coal consumption. A heavy, black fire means low temperature, low superheat and large coal consumption. Firemen who carefully follow the above outlined practice will save coal for the company and make their own work easier.

57. The engineman should be sure that the superheater damper is open while using steam, and closed when steam is shut off. This can be ascertained by observing the counterweight on the right-hand side of the smoke box attached to the damper. When the counterweight is up the damper is open, and when down the damper is closed. When the locomotive is shut off and the blower is used, the engineer should observe that the damper is in a closed position. If the damper is open with the blower on, the superheater tubes are apt to be burned out, due to no steam circulating through the superheater tubes. When using steam, the piston in damper cylinder should always move its entire stroke and stop against its seat, in order to prevent loss of cylinder lubrication past the piston. A leak at this point will permit steam to escape at end of drip pipe attached to damper cylinder, and should be reported promptly.

58. Leaks in front end of superheater units, steam pipes and exhaust column, fire tubes stopped up, and derangement of draft appliances not only interfere with the proper steaming of the locomotive, but reduce the degree of superheat. Blows in cylinder and valve packing will cause scoring, due to removal of oil from the wearing surfaces. All leaks such as those mentioned above should be reported promptly by the engineman, because, if neglected, they seriously affect the economical operation of the locomotive.

While your committee recognizes that a number of books and treatises on the subject of economical use of fuel in locomotives have been written, we feel that the majority have been too lengthy, too technical and too cumbersome to be of proper use to the men concerned, especially the new firemen, who have generally lacked adequate preliminary instruction here-

tofore. With this end in view, we have tried to point out those cardinal features which are of vital importance to the end desired, and also for the reason that many roads have no instructions on this most important subject of fuel economy. Your committee, therefore, hopes that this subject has been treated in a manner to warrant its incorporation into the Association's recommended practices.

By treating a few fundamental subjects in considerable detail, your committee has endeavored to lay a firm foundation for an exhaustive study of fuel economy, which will be extended into the future. The advantages of designing locomotives to have the maximum efficiency, and the proper instruction of the men who operate these locomotives, have been clearly set forth.

RULES FOR BOILER WASHING. RECOMMENDED PRACTICE.

In 1915 the following rules for boiler washing were adopted as Recommended Practice:

Frequency of Washing.

1. All locomotives in service must have boilers washed at least once every thirty days, or more frequently if conditions require.

Cooling Boilers.

2. Boilers should be thoroughly cooled before being washed, excepting at points where improved hot water wash-out systems are installed. When boilers are cooled in the natural way without the use of water, the steam should be blown off, but the water must be retained above the top of crown sheet and boiler allowed to stand until the temperature of the steel in fire box is reduced to about ninety degrees, or so that it feels cool to the hand; then the water is drawn off and the boiler washed. When the engine can not be spared from service sufficiently long for it to be cooled in this manner before washing, proceed as follows:

Use of Injector Cooling Boilers.

3. When there is sufficient steam pressure, start the injector and fill the boiler with water until the steam pressure will no longer work the injector. Then connect water-pressure hose to feed pipe between engine and tender and fill the boiler full, allowing the remaining steam pressure to blow through syphon cock or some other outlet at top of the boiler. Open blow-off cock and allow water to escape, but not faster than it is forced in through the check, so as to keep the boiler completely filled until the temperature of the steel in the fire box is reduced to about ninety degrees, then remove all plugs and allow boiler to empty itself.

How to Wash a Boiler.

4. Remove all wash-out plugs. Begin washing through holes on side of boiler opposite front end of crown sheet. Wash top of crown sheet at front end, using Nozzle No. 1 or 2. Then use Nozzles 3 and 4 to wash between rows of crown bars and bolts at right angles to nozzle, directing the stream toward the back end of crown sheet. After washing through holes near front end of crown sheet, use holes in their respective order toward the back of the crown sheet. The object of this method is to work the mud and scale from the crown sheet toward the side and back legs of the boiler and prevent depositing it on the back ends of the flues.

Washing Crown Sheet.

5. Next wash crown sheet from boiler head, using Nozzles 1 and 3 or 6. When Nos. 3 or 6 are employed, the swivel connection with hose should be used and nozzle should be inserted to the front end of crown sheet and slowly drawn back and revolved at the same time, so as to wash top of boiler and all radial stays or bolts as well as the crown sheet.

Washing Flues.

6. Wash back end of flues through holes in connection sheet, using Nozzles Nos. 1, 5 and 6, and revolve same by means of swivel connection when the curved nozzles are used. The same nozzles are to be used and the same system followed when washing any part of the flues or feed-water heater flues.

Washing Back Head Water Spaces.

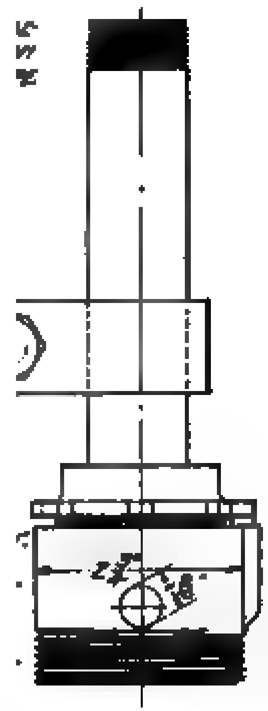
7. Wash the water space between back head and fire-box door sheet through the holes in back head with Nozzle No. 6, being careful to remove all scale and mud above and below fire-door hole.

Washing Arch Tubes.

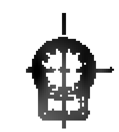
8. Arch tubes must be washed and scraped clean with scrapers or pneumatic cleaners every time the boiler is washed. If scale is allowed to form in arch tubes the metal becomes overheated and bulges are formed, and, if allowed to remain, tube warps out of line with holes, strains are set up and cracks develop, and the tube is very dangerous and liable to pull out or explode. Therefore a locomotive should not be allowed to leave a terminal with dirty arch tubes, and all concerned are instructed to strictly comply with the rule.

Note.— The condition of an arch tube as to scale on the water side can readily be determined by the presence of clinker adhering on the fire side. If an arch tube is clean on the water side it will be clean and smooth on the fire side. The condition of fire-box sheets can usually be determined by similar evidence. It may be laid down as a general rule that

WASHOUT NOZZLES.



... L WASHOUT NOZZLE



clean fire boxes on the water side are clean and smooth on the fire side. Any clinker adhering or sand-paper roughness on the fire side indicates scale formation opposite.

Washing Side-sheet Water Spaces.

9. Now return to holes on side of boiler opposite crown sheet, using Nozzles 5 and 6, and revolve same so as to thoroughly wash down side sheets and staybolts, making sure that all spaces on side of fire box are clear of mud and scale. Then wash through holes near check valves near front end of boiler, using Nozzles 1 and 5 or 6, with swivel connection.

Washing Barrel of Boiler.

10. Then wash through hole in bottom of barrel of boiler near the rear end, and wash toward the front end. If engine has no mud drum, wash toward the throat sheet with Nozzles 5 or 6. Then use straight nozzle directly against the flues, reaching as great space as possible in all directions. Then use the bent nozzle through the front hole in bottom of barrel, and also the straight nozzle in same manner as above, until certain that the flues and spaces between the flues and barrel are as clean as it is possible to make them.

Washing Mud Ring.

11. Then use Nozzles Nos. 5 and 6 in the side and corner holes of water legs, revolving same thoroughly to clean the side sheets, and finally clean off all scale and mud from the mud ring by means of straight nozzles in the corner holes.

Inspection after Washing.

12. It must not be assumed that because clear water runs from the holes that the boiler is cleaned, but all spaces must be examined carefully with rod and light, and, if necessary, use a pick, steel scraper or other tools, to remove accumulated scale.

Filling Boilers.

13. When cooling and filling boilers, they must be filled through the injector check. The injector steam pipe valve at the fountain must be closed. Filling up boilers through blow-off cocks will not be permitted except at hot water boiler washing plants and when hot water is being used.

LUMBER SPECIFICATIONS.

RECOMMENDED PRACTICE.

In 1910 a joint committee of the American Railway Master Mechanics' Association and this Association working in conjunction with the Railway Storekeepers' Association and the various Lumber Manufacturers' Associations, submitted specifications and grading rules for car and locomotive lumber, which, on motion, were ordered submitted to letter ballot and adopted as Recommended Practice. They are as follows:

In order to have standard descriptions of the various woods used by railroads, the following standard names for car and locomotive lumber were agreed upon by the Joint Committee:

LUMBER SPECIFICATIONS.

Description of various woods used by railroad companies for car and locomotive lumber.

1. *Ash* .... To cover White, Black, Blue, Green and Red Ash.
2. *Basswood* .... To cover Linden, Linn, Lind or Lime-tree.
3. *Beech* .... To cover Red and White Beech.
4. *Birch* .... To cover Red, White, Yellow and Black Birch.
5. *Buckeye.* .... To cover wood from Horse-chestnut tree.
6. *Butternut* .... To cover wood from tree of that name, also known as White Walnut.
7. *Cherry* .... To cover Sweet, Sour, Red, Black and Wild Cherry.
8. *Chestnut* .... To cover wood from tree of that name.
9. *Cottonwood* .... To cover wood from tree of that name. (Do not confuse with Popple or Poplar.)
10. *Cypress* .... To cover Red, Gulf, Yellow and East Coast Cypress, also known as Bald Cypress.
11. *Elm—soft* .... To cover White, Water, Gray, Red or Slippery and Winged Elm.
12. *Elm—rock* .... To cover Rock or Cork Elm.
13. *Douglas Fir* .... To cover Yellow, Red, Western, Washington, Oregon, Puget Sound Fir or Pine, Norwest and West Coast Fir.
14. *Gum* .... To cover Red Gum, Sweet Gum or Satin Walnut.
15. *Hemlock* .... To cover Southern and Eastern Hemlock; that is, Hemlock from all States east of and including Minnesota.
16. *Western Hemlock* .... To cover Hemlock from the Pacific Coast.
17. *Hickory* .... To cover Shellbark, Kingnut, Mockernut Pignut, Black, Shagbark and Bitternut.

18. *Western Larch* ....To cover the species of Larch or Tamarack from the Rocky Mountain and Pacific Coast regions.
19 *Maple—soft* ....To cover Soft and White Maple.
20. *Maple—hard* ....To cover Hard, Red, Rock and Sugar Maple.
21. *White Oak* ....To cover White, Burr or Mossy Cup, Rock, Post or Iron, Overcup, Swamp Post, Live, Chestnut or Tan Bark, Yellow or Chinquapin and Basket or Cow Oak.
22. *Red Oak* ....To cover Red, Pin, Black, Water, Willow, Spanish, Scarlet, Turkey, Black Jack or Barn and Shingle or Laurel Oak.
23. *Pecan* ....To cover wood from tree of that name.
24. *Southern Yellow Pine*.To cover Long-leaf and Short-leaf Yellow Pine grown in the Southern States.
25 *White Pine* ....To cover wood from tree of that name grown in Maine, Michigan, Wisconsin, Minnesota and Canada.
26. *Norway Pine* ....To cover Norway or Red Pine grown in Michigan, Minnesota, Wisconsin and Canada.
27. *Idaho White Pine* ....To cover variety of White Pine grown in western Montana, northern Idaho and eastern Washington.
28 *Western Pine* ....To cover timber known as White Pine grown in Arizona, California, New Mexico, Colorado, Oregon and Washington; sometimes known as Western Yellow or Ponderosa Pine, or California White Pine or Western White Pine.
29 *Poplar* ....To cover wood from the Tulip Tree, otherwise known as Whitewood, Yellow Poplar and Canary Wood.
30 *Redwood* ....To cover wood from tree of that name.
31. *Spruce* ....To cover Eastern Spruce; that is, the Spruce timber coming from points east of and including Minnesota and Canada, covering White, Red and Black Spruce.
32. *Western Spruce* ......To cover the Spruce timber from the Pacific Coast.
33 *Sycamore* ....To cover wood from tree of that name, otherwise known as Buttonwood.
34 *Tamarack* ....To cover Tamarack or Eastern Tamarack, grown in States east of and including Minnesota.
35. *Tupelo* ....To cover Tupelo Gum and Bay Poplar.
36. *Walnut* ....To cover Black Walnut (for White Walnut, see Butternut).

CLASSIFICATION, GRADING AND DRESSING RULES FOR NORTHERN PINE CAR MATERIAL, INCLUDING WHITE AND NORWAY PINE AND EASTERN SPRUCE.

1. *Norway Pine.* To cover Norway or Red Pine grown in Michigan, Minnesota, Wisconsin and Canada.

White Pine to cover wood from tree of that name grown in Maine, Michigan, Wisconsin, Minnesota and Canada.

Spruce to cover Eastern Spruce; that is, the Spruce timber coming from points east of and including Minnesota and Canada, covering White, Red and Black Spruce.

2. *Northern Pine Lumber* shall be graded and classified according to the following rules and specifications as to quality, and dressed stock shall conform to the subjoined table of standard sizes, ***except where otherwise expressly stipulated between buyer and seller.***

3. Recognized defects in Northern Pine are knots, knotholes, splits, shake, wane, wormholes, pitch pockets, torn grain, loosened grain, sap, sap stain, checks and rot.

KNOTS.

4. Knots shall be classified as pin, small and large or coarse, as to size, and round or spike, as to form, and as sound, loose, encased, pith and rotten, as to quality.

5. A pin knot is sound and shall not exceed ½ inch in diameter.

6. A small knot is larger than a pin knot and shall not exceed 1½ inches in diameter.

7. A large or coarse knot is one of any size over 1½ inches in diameter.

8. A round knot is oval or circular in form.

9. A spike knot is one sawn in a lengthwise direction.

The mean or average diameter of knots shall be considered in applying and construing these rules.

10. A sound knot is one solid across its face; is as hard as the wood it is in and is so fixed by growth or position that it will retain its place in the piece.

11. A loose knot is not firmly set, but still retains its place in the piece.

12. A pith knot is a sound knot with a pith hole not more than ¼ inch in diameter.

13. An encased knot is one surrounded wholly by bark or pitch.

14. A rotten knot is one not as hard as the wood it is in.

EXHIBIT A — NORTHERN WHITE PINE.

FIG. 1.— PIN KNOTS.

FIG. 2.— SMALL AND ROUND KNOT.

FIG. 3.—LARGE KNOT.

FIG. 4.—SPIKE KNOT.

Fig. 5.—Sound Knots.

Fig. 6.—Loose Knot.

FIG. 8.—SMALL PITCH POCKET.

PITCH.

15. Pitch pockets are openings between the grain of the wood containing more or less pitch or bark, and shall be classified as small, standard and large pitch pockets.

16. A small pitch pocket is one not over ⅛ of an inch wide.

17. A standard pitch pocket is one not over ⅜ of an inch wide, or 3 inches in length.

18. A large pitch pocket is one over ⅜ of an inch wide or over 3 inches in length.

19. A pitch pocket showing open on both sides of the piece ⅛ of an inch or more in width shall be considered the same as a knothole.

WANE.

20. Wane is bark, or the lack of wood, from any cause, on edge.

SAP.

21. White or bright sap shall not be considered a defect in any of the grades provided for and described in these rules, except where stipulated.

MISCELLANEOUS.

22. Defects in rough stock caused by improper manufacture and drying will reduce grade, unless they can be removed in dressing such stock to standard sizes.

23. All lumber for uses described in these rules shall be inspected on the face side to determine the grade, and the face side is the side showing the best quality or appearance.

24. Chipped grain consists in a part of the surface being chipped or broken out in small particles below the line of the cut, and as usually found should not be classed as torn grain, and shall not be considered a defect.

25. Torn grain consists in a part of the wood being torn out in the dressing. It occurs around knots and curly places, and is of four distinct characters; slight, medium, heavy and deep.

Slight torn grain shall not exceed 1-32 of an inch in depth, medium 1-16 of an inch, and heavy ⅛ of an inch. Any torn grain heavier than ⅛ of an inch shall be termed deep.

26. The grade of all regular stock shall be determined by the number, character and position of the defects visible in any piece. The enumerated defects herein described admissible in any grade are intended to be descriptive of the coarsest pieces *such grades may contain*, but the average quality of the grade shall be midway between the highest and lowest pieces allowed in the grade.

27. Lumber and timber sawed for specific purposes must be inspected with a view to its adaptability for the use intended.

28. *All dressed stock shall be measured strip count, viz.: Full size of rough material necessarily used in its manufacture.*

29. Lumber must be accepted on grade in the form in which it was shipped. Any subsequent change in manufacture or mill work will prohibit an inspection for the adjustment of claims, except with the consent of all parties interested.

30. The foregoing general observations shall apply to and govern the application of the following rules. The rules referred to under Sections 31, 32, 33, 34 and 35 govern 4 or 6 inch strips, and are intended to cover strips used for car siding, car lining and car roofing.

*B and Better White Pine.**

31. Material of this grade shall be practically clear and free of all defects, except will admit of not exceeding four pin knots, and bright sap not to exceed 25 per cent of the face of the piece.

C and Better Norway Pine.

32. Bright sap is no defect in this grade and stained sap will be admitted to the extent of not exceeding 1-5 the surface of the face of the piece, if not in combination with other defects. This grade shall be free from shake, rot and splits, but will admit of not exceeding four pin knots.

No. 1 Common White Pine, Norway Pine and Eastern Spruce.

33. This grade admits of small sound knots, but shall be free from large or coarse knots, knotholes, should have practically no shake, wane or rot, but will admit of bright sap to any extent.

No. 2 Common White Pine, Norway Pine and Eastern Spruce.

34. This grade is similar to No. 1, described above, except that it will admit of spike knots, bright or stained sap, slight shake, slight wane on reverse side, but not a serious combination of any of these defects.

No. 3 Common White Pine, Norway Pine and Eastern Spruce.

35. This grade, in addition to the defects mentioned in No. 2, described above, will also admit of large or coarse knots, more shake, sap, wane on reverse side that does not affect the tongue or groove and torn or loosened grain, checks, pin wormholes and splits, but no loose knots or knotholes, nor a serious combination of the defects named.

No. 1 Common Norway Pine Car Decking or Flooring.

36. This grade will admit of sound knots, any amount of sap, and shall be free from shake, wane, rot and large or coarse spike knots.

37. STANDARD LENGTHS.

CAR SIDING — 8, 9, 10 and 12 feet or multiples.
CAR ROOFING — 5 feet or multiples.
CAR LINING — 8, 9, 10, 12, 14, 16, 18 and 20 feet or multiples.
CAR DECKING — 9 and 10 feet or multiples.

All orders shall be shipped in standard lengths, unless otherwise specified, but no lengths of either car siding, lining or roofing shall be shipped except in the lengths specified or multiples thereof. Those who do not desire stock shipped in multiple lengths should so specify.

CLASSIFICATION, GRADING AND DRESSING RULES FOR SOUTHERN YELLOW PINE CAR MATERIAL.

1. *Southern Yellow Pine.*— To cover Long-leaf and Short-leaf Yellow Pine grown in the Southern States.

2. *Southern Yellow Pine Lumber* shall be graded and classified according to the following rules and specifications as to quality, and dressed stock shall conform to the subjoined table of standard sizes, *except where otherwise expressly stipulated between buyer and seller.*

3. Recognized defects in Southern Yellow Pine are knots, knotholes, splits (either from seasoning, ring hearts or rough handling), shake, wane, red heart, pith, rot, rotten streaks, dote, red heart, wormholes, pitch streaks, pitch pockets, torn grain, loosened grain, seasoning or kiln checks and sap, sap stains and imperfect manufacture.

KNOTS.

4. Knots shall be classified as pin, standard and large, as to size; and round and spike, as to form; and as sound, loose, encased, pith and rotten, as to quality.

5. A pin knot is sound and not over ½ inch in diameter.

6. A standard knot is sound and not over 1½ inches in diameter.

7. A large knot is one any size over 1½ inches in diameter.

8. A round knot is oval or circular in form.

9. A spike knot is one sawn in a lengthwise direction.

The mean or average diameter of knots shall be considered in applying and construing these rules.

10. A sound knot is one solid across its face; is as hard as the wood it is in and is so fixed by growth or position that it will retain its place in the piece.

11. A loose knot is one not held firmly in place by growth or position.

12. A pith knot is a sound knot with a pithhole not more than ¼ inch in diameter.

13. An encased knot is one surrounded wholly or in part by bark or pitch. Where the encasement is less than ⅛ of an inch in width on both sides, not exceeding one-half the circumference of the knot, it shall be considered a sound knot. (See Sections 10 and 17.)

14. A rotten knot is one not as hard as the wood it is in.

EXHIBIT B — SOUTHERN YELLOW PINE.

FIG. 1.— LOOSE KNOT.

FIG. 2.— PITH KNOT.

FIG. 3.— ENCASED KNOT.

FIG. 4.— ROTTEN KNOT.

Fig. 5.—Pin Knot.

Fig. 6.—Standard Knot.

FIG. 7.— LARGE KNOT.

FIG. 8.— SPIKE KNOT.

PITCH.

15. Pitch pockets are openings between the grain of the wood containing more or less pitch or bark, and shall be classified as small, standard and large pitch pockets.

16. A small pitch pocket is one not over ⅛ of an inch wide.

A standard pitch pocket is one not over ⅜ of an inch wide or 3 inches in length.

A large pitch pocket is one over ⅜ of an inch wide or over 3 inches in length.

17. A pitch pocket showing open on both sides of the piece ⅛ of an inch or more in width shall be considered the same as a knothole.

18. A pitch streak is a well-defined accumulation of pitch at one point in the piece, and when not sufficient to develop a well-defined streak, or where fibre between grains is not saturated with pitch, it shall not be considered a defect.

19. A small pitch streak shall be equivalent to not over one-twelfth the width and one-sixth the length of the piece it is in.

A standard pitch streak shall be equivalent to not over one-sixth the width and one-third of the length of the piece it is in.

(See Exhibit C.)

EXHIBIT C.

FIG. 9.— PITCH POCKET.

FIG. 10.— PITCH STREAK.

WANE.

20. Wane is bark, or the lack of wood, from any cause, on the edge.

SAP.

21. Bright sap shall not be considered a defect in any of the grades provided for and described in these rules, except where stipulated.

SHAKE.

22. Shakes are splits or checks in timbers which usually cause a separation of the wood between annual rings.

Through Shake: A shake which extends between two faces of a timber.

Ring Shake: An opening between the annual rings.

MISCELLANEOUS.

23. Defects in rough stock caused by improper manufacture and drying will reduce grade, unless they can be removed in dressing such stock to standard sizes.

24. All stock except car sills and framing shall be inspected on the face side to determine the grade. Stock surfaced one side, the dressed surface shall be considered the face side. Stock rough or dressed two sides, the best side shall be considered the face, but the reverse side of all such stock shall not be more than one grade lower.

25. Pieces of siding, lining or roofing with 3-16 of an inch or more of tongue will be admitted in any grade, provided it does not run more than one-third the length of the piece.

26. In all grades lower than B and better, wane on the reverse side, not exceeding one-third the width and one-sixth the length of any piece is admissible; provided the wane does not extend into the tongue, or over one-half the thickness below the groove.

27. Chipped grain consists in a part of the surface being chipped or broken out in small particles below the line of the cut, and as usually found shall not be classed as torn grain and shall not be considered a defect.

28. Torn grain consists in a part of the wood being torn out in dressing. It occurs around knots and curly places, and is of four distinct characters — slight, medium, heavy and deep.

Slightly torn grain shall not exceed 1-32 of an inch in depth; medium, 1-16 of an inch; heavy, ⅛ of an inch; any torn grain heavier than ⅛ of an inch shall be termed deep.

29. Loosened grain consists in a point of one grain being torn loose from the next grain. It occurs on the heart side of the piece and is a serious defect, especially in flooring.

30. *Rot, Dote and Red Heart:* Any form of decay which may be evident either as a dark-red discoloration not found in the sound wood, or the presence of white or red rotten spots, shall be considered as a defect.

Firm red heart shall not be considered a defect in any of the grades of Common Lumber.

31. The grade of all regular stock shall be determined by the number, character and position of the defects visible in any piece. The enumerated defects herein described admissible in any grade are intended to be descriptive of the *coarsest* pieces *such grades may contain*, but the average quality of the grade shall be midway between the highest and lowest pieces allowed in the grade.

32. Lumber and timber sawed for specific purposes must be inspected with a view to its adaptability for the use intended.

33. *All dressed stock shall be measured strip count, viz.: Full size of rough material necessarily used in its manufacture.*

34. Equivalent means equal, and in construing and applying these rules, the defects, whether specified or not, are understood to be equivalent in damaging effect to those mentioned applying to stock under consideration.

35. Lumber must be accepted on grade in the form in which it was shipped. Any subsequent change in manufacture or millwork will prohibit an inspection for the adjustment of claims, except with the consent of all parties interested.

36. The foregoing general observations shall apply to and govern the application of the following rules:

37. *B and Better Car Siding, Lining and Roofing* will admit any two of the following, or their equivalent of combined defects: Sap stain not to exceed five per cent; firm red heart not to exceed fifteen per cent of the face; three pin knots; one standard knot; three small pitch pockets; one standard pitch pocket; one standard pitch streak; slight torn grain, or small kiln or season checks. Where no other defects are contained, six small pin wormholes will be admitted.

38. *Select Car Siding* will admit of one standard pitch streak, one standard pitch pocket, or their equivalent; and, in addition, will admit of not exceeding five pin knots and two standard knots, or their equivalent; ten per cent sap stain; firm red heart; slight shake; heavy torn grain; defects in manufacture or seasoning checks. Pieces otherwise good enough for B, but containing a limited number of pin wormholes shall be graded *select*. This grade is intended to be accumulated from running B and Better stock, and will consist of all the droppings which do not contain defects in excess of those mentioned in this paragraph.

39. *No. 1 Common Car Siding* will admit of the following defects or their equivalent: Sound knots, not over one-half of cross section of the piece at any point throughout its width; three pin knots or their equivalent; wane ½ inch deep on edge not exceeding 1½ inches wide and one-half the length of the piece; torn grain; pitch pockets; pitch; sap stain; seasoning checks; slight shakes; firm red heart and a limited number of small wormholes well scattered. This grade is intended to be worked from fencing stock, either kiln or air dried.

40. *Select Car Lining and Roofing* will admit of one standard pitch streak; one standard pitch pocket, or their equivalent, and, in addition, sound knots not over one-half the width of the piece in the rough; ten per cent sap stain; firm red heart; slight shakes; heavy torn grain; defects in manufacture, or seasoning checks. Pieces otherwise good enough for B, but containing a limited number of pin wormholes shall be graded *select* This grade is intended to be accumulated from running B and Better stock, and will consist of all the droppings which do not contain defects in excess of those mentioned in this paragraph.

41. *No. 1 Common Car Lining and Roofing* will admit of the following defects or their equivalent: Sound knots not over one-half the cross section of the piece at any point throughout its length; three pin knots or their equivalent; torn grain; pitch pockets; sap stains; seasoning checks; firm red heart, and a limited number of pin or small wormholes well scattered. This grade is intended to be worked from fencing stock, either kiln or air dried.

42. *Standard Patterns.* (Insert B/P reference, showing net sizes after working.)

43. *All-heart Car Decking or Flooring* will admit sound knots not over one-third of the cross section of the piece at any point throughout its length, provided they are not in groups; pitch pockets; firm red heart; shake and seasoning checks which do not go through the piece; loose or heavy torn grain, or other machine defects, which will lay without waste or will not cause a leakage in cars when loaded with grain. Must be strictly *all heart* on both sides and both edges.

44. *Heart Face Car Decking or Flooring* will admit of sound knots not over one-third the cross section of the piece at any point throughout its length; provided they are not in groups; pitch pockets; firm red heart; shake and seasoning checks which do not go through the piece; loosened or heavy torn grain, or other machine defects, which will lay without waste, or will not cause a leakage in cars when loaded with grain. Will admit of any amount of sap provided all of the face side of the piece is strictly all heart.

45. *No. 1 Common Car Decking or Flooring* will admit of sound knots not over one-half the cross section of the piece at any point throughout its length, provided they are not in groups; pitch pockets; sap stain; firm red heart; shake and seasoning checks which do not go through the piece; a limited number of pin wormholes; loosened or heavy torn grain, or other machine defects, which lay without waste, or will not cause a leakage in cars when loaded with grain.

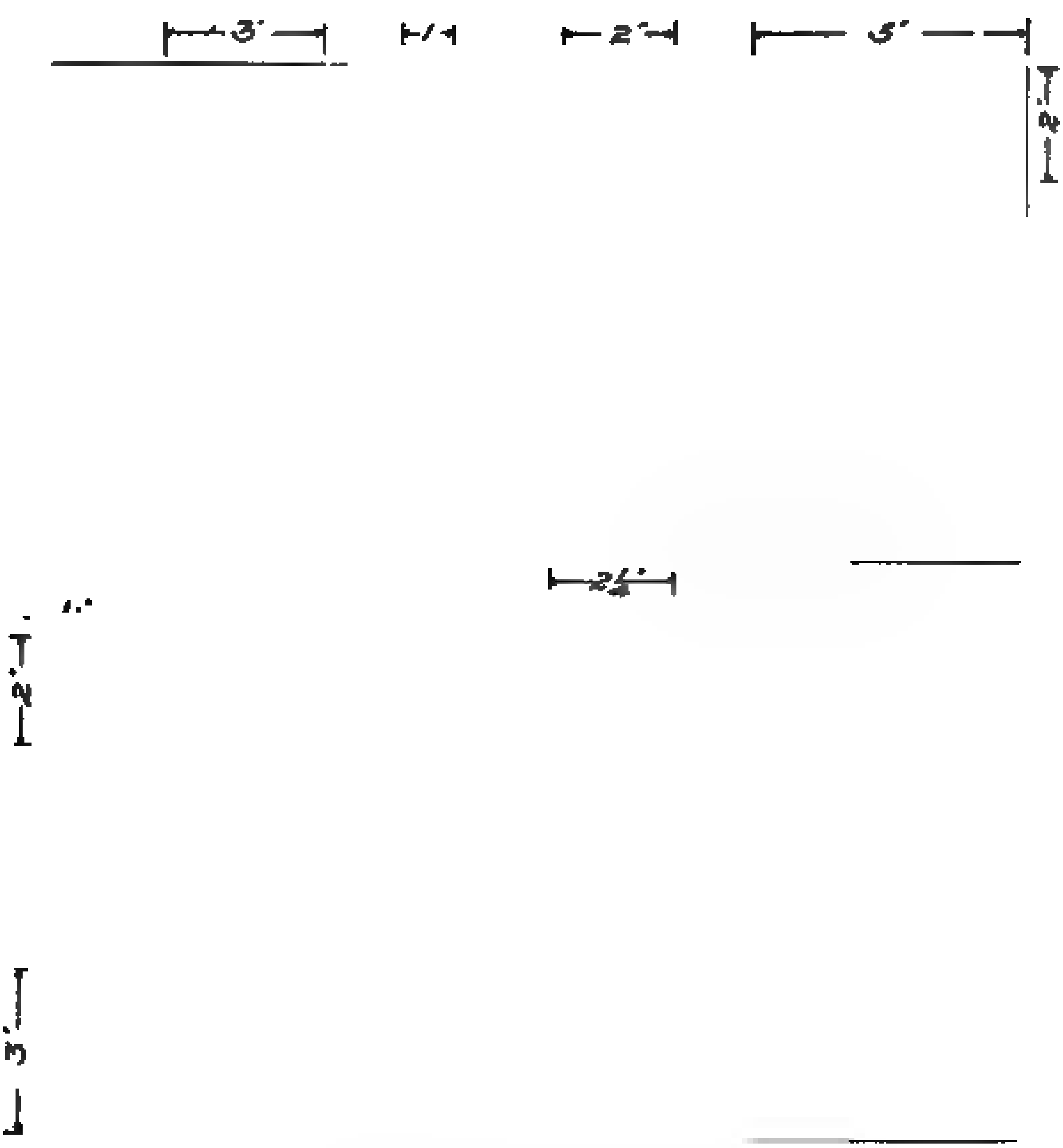
46. STANDARD LENGTHS:

CAR SIDING — 8, 9, 10 and 12 feet or multiples.

CAR LINING — 8, 9, 10, 12, 14, 16, 18 and 20 feet or multiples.

CAR ROOFING — 5 feet or multiples.

CAR DECKING OR FLOORING — 9 and 10 feet or multiples.



LUMBER SECTIONS.
SHOWING 75 % HEART.
ALL SECTIONS 5"x3" TOTAL SURFACE 20"

All orders shall be shipped in standard lengths, unless otherwise specified, but no lengths of either car siding, lining or roofing shall be shipped, except in the lengths specified or multiples thereof. Those who do not desire stock shipped in multiple lengths should so specify.

CAR SILLS AND FRAMING.

47. *No. 1 Common Heart Car Sills and Framing* will admit of sound knots, provided they are not in groups, the mean or average diameter of which shall not exceed two (2) inches; pitch; pitch pockets; slight shake; seasoning checks, or other defects which will not impair its strength more than the defects aforementioned. Must be sawed from sound timber, free from doty or rotten red heart and true to measurements, or at least the measurements at no point on the sill shall be less than the size required.

Measurement of the girth at any point throughout the length of the piece must show at least 75 per cent heartwood.

Cubical contents shall not be used as basis for obtaining percentage of heartwood under this rule.

48. *No. 1 Common Car Sills and Framing* will admit of sound knots, provided they are not in groups, the mean or average diameter of which shall not exceed two (2) inches; pitch; pitch pockets; slight shake; seasoning checks; sap; sap stain, or other defects which will not impair its strength more than the defects aforementioned. Must be sawed true to measurements and from sound timber free from doty or rotten red heart; must be square cornered, except that one (1) inch of wane on one corner or one-half (½) inch of wane on two corners is admissible.

49. *Sizes* up to 6 inches in width shall measure full when green, and not more than ⅛ inch scant when dry or part dry. Sizes 6 to 12 inches in width shall measure full when green and not more than ¼ inch scant when dry or part dry. Sizes 12 to 16 inches in width shall measure full when green and not more than ⅜ inch scant when dry or part dry. Unless otherwise specified, one-fourth inch shall be allowed for each side which is to be dressed. In pieces 3 by 6 inches and under when ordered in lengths exceeding 30 feet, sound knots shall not exceed one-quarter the width of the face through which they project, and the grain shall not cross sufficiently to impair the strength.

CLASSIFICATION AND GRADING RULES FOR LOCOMOTIVE, FREIGHT AND PASSENGER CAR OAK.

GENERAL INSTRUCTIONS.

Those who are not familiar with the anatomy of the oak tree should, when reading over these rules, take into consideration that the rule describes the poorest piece that goes into the grade and that a large percentage is above the grade described.

DEFINITION OF OAK FOR CONSTRUCTION PURPOSES.

The term "Construction Oak" means all such products of Oak in which the strength and durability of the timber is the controlling element in its selection and use. The following is a list of products which are recommended for consideration as "Construction Oak":

I.— Construction Oak.

(A)
(B) Cover Maintenance of Way Material.
(C)

(D) *Locomotive Timbers:* Sills, End and Truck Timbers.

(E) *Car Timbers:* Car Framing, including Upper Framing, Car Sills, End and Truck Timbers, Car Decking, Inside Lining.

(F)
(G)
(H)
(I) Cover Maintenance of Way Material.
(J)
(K)
(L)

II.— Standard Defects.

Definition of "Defect." — Fault, Blemish, Mark of Imperfection that will materially injure the strength.

Measurements which refer to the diameter of knots or holes shall be considered as referring to the mean or average diameter.

II.— (A) Knots.

(1) *Sound Knot.* A sound knot is one which is solid across its face, and which is as hard as the wood surrounding it; it may be any color and contain checks.

(2) *Loose Knot.* A loose knot is one not firmly held in place by growth or position.

(3) *Pith Knot.* A pith knot is a sound knot with a pith hole not more than ¼ inch in diameter in the center.

(4) *Rotten Knot.* A rotten knot is one that is not sound and not as hard as the wood surrounding it.

(5) *Pin Knot.* A pin knot is a sound knot not over ¾ inch in diameter.

(6) *Standard Knot.* A standard knot is a knot not over 2 inches in diameter.

(7) *Large Knot.* A large knot is a sound knot more than 2 inches in diameter.

(8) *Round Knot.* A round knot is one which is oval or circular in form.

(9) *Spike Knot.* A spike knot is one sawn in lengthwise direction. The mean or average width shall be considered in measuring this knot.

(10) *Bird Peck.* Bruises apparently caused by bird pecks during the growth process of the timber. Considered no defect.

FIG. 1.— SOUND KNOT.

FIG. 2.—LOOSE KNOT.

FIG. 3.—PITH KNOT.

Fig. 4.—Rotten Knot.

Fig. 5.— Pin Knot.

Fig. 6.— Standard Knot

FIG. 7.—LARGE KNOT.

FIG. 8.—SPIKE KNOT.

Fig. 9.— Burl Knot.

Fig. 10.— Bird Peck.

II.— (B) Worm Defects.

(1) *Pin Wormholes.* Pin wormholes are very small holes caused by minute insects or worms. These holes usually are not over 1-16 inch in diameter, or smaller, and the wood surrounding them is sound and does not show any evidences of the wormhole having any effect on the wood other than the opening.

(2) *Spot Worm Defects.* (Also known as Flag Worm Defects.) Spot worm defects are caused, like pin wormholes, by minute insects or worms working on the timber during its growth. The size of the hole is about the same as pin wormholes, but the surrounding wood shows a colored spot as evidence of the defect. This spot is usually sound and does not affect the strength of the piece.

(3) *Grub Wormholes.* Grub wormholes are usually from about 1/8 to 3-16 inch in width and vary in length from about 3-16 inch to 1 inch, and are caused by grub worms working in the wood.

(4) *Wooden Rafting Pinholes.* This defect sometimes appears on river timber which has been rafted and holes bored in the solid wood for tying the timber, and a solid plug or pin driven in the hole filling it completely. These defects must be treated and considered the same as knot defects. Ordinary metal rafting pin or chain dog hole is considered no defect.

Fig. 1.— Pin Worm Defects.

Fig. 2.—Spot Worm Defects.

Fig. 3.—Metal Rafting Pinhole.

Fig. 4.—Grub Wormholes.

FIG. 5.—WOODEN RAFTING PINHOLES.

II.—(C) SAP.

Definition of "Sap."—The alburnum of a tree—the exterior part of the wood next to the bark; sap wood not considered a defect.

Sound Heart. The term sound heart is used in these rules whenever heart of piece is split or opened and shows on outside of piece and its condition is sound and solid, not decayed. Openings between annual rings are checks not considered a defect.

II.—(D) WANE.

Wane is bark or lack of wood from any cause on edges of timber.

II.—(E) SHAKES.

Definition of "Shakes."—Shakes are splits or checks in timber which usually cause a separation of the wood between the annual rings.

(1) *Ring Shakes.* Ring shakes are openings between the annual rings usually showing only on the end of the timber.

(2) *Through Shakes.* Through shakes are shakes which extend between two faces of the timber.

(3) *Checks.* A small crack in the wood due to seasoning; not considered a defect.

II.—(F) GRAIN.

Crooked or Cross Grain. Crooked or cross grain occurs where the grain crosses the piece within a section of 24 inches in running length of the piece. This is only considered a defect in certain smaller sizes of dimension for specific purposes.

II.— (G) Rot.

Any form of decay which may be detected as giving the timber a doty or rotten texture is a rot defect, including what is commonly known as dry rot. Water stain, or what are sometimes called scalded or burned spots, usually caused by timber lying in the water under certain conditions before it is sawed, and burned spots where the timber is improperly piled green, not considered defects, as they do not affect the strength of the piece.

III.— Standard Names for Construction Oak.

Standard names for Construction Oak timbers; White Oak and Red Oak. Unless specially mentioned, these terms include the following:

White Oak.	*Red Oak.*
White Oak.	Red Oak.
Burr or Mossy Cup Oak.	Pin Oak.
Rock Oak.	Black Oak.
Post or Iron Oak.	Water Oak.
Overcup.	Willow Oak.
Swamp Post Oak.	Spanish Oak.
Live Oak.	Scarlet Oak.
Chestnut or Tan Bark Oak.	Turkey Oak.
Basket or Cow Oak.	Black Jack or Barn Oak.
Yellow or Chinquapin Oak.	Shingle or Laurel Oak.

Term: Mixed Oak means any kind of oak.

IV.— Standard Specifications for Structural Oak Timbers.

(1) *General Requirements.* Except as noted, all structural timbers shall be white oak, to be sound timber and sawed specified sizes; free from ring shakes, crooked grain, rotten knots, large knots in groups, rot, dote and wane in amounts greater than allowed in these specifications.

(2) *Boxed Hearts.* Boxed hearts are permitted in pieces 5 by 5 square and larger. The center of the heart shall be boxed as near the center of the piece as practical, and not to exceed 30 per cent of the pieces can have the center of the heart nearer than 1½ inches from any face; 20 per cent may show one heart face, corner or edge, not to exceed 75 per cent of the length of the piece.

IV.— (3) Wane.

EXPLANATION.

The term 20 per cent of number of pieces or amount shipped refers to each item and size of each car shipped.

(a) Pieces 5 by 5 to 8 by 8 square may show 1 inch wane, side measurement on any two corners or edges, and this wane not to exceed more than 25 per cent of the length of the piece singly, or 50 per cent in

aggregate. In the absence of wane on all corners excepting one, the one corner may contain wane 50 per cent of the length of the piece as above described; not to exceed 20 per cent of number of pieces may have this defect.

(b) Pieces over 8 by 8, including 12 by 12, square may show 1½ inches wane, side measurement, edge of any two corners or edges, and this wane not to exceed more than 33⅓ per cent of the length of the piece singly, or 66⅔ per cent in aggregate. In the absence of wane on all corners excepting one, the one corner may contain wane 66⅔ per cent of the length of the piece as above described; not to exceed 20 per cent of number of pieces may have this defect.

(c) Pieces over 12 by 12 square may show 1¾ inches, side measurement, any two corners or edges, and this wane not to extend more than 40 per cent of the length of the piece singly, or 80 per cent in aggregate. In the absence of wane on all corners excepting one, the one corner may contain wane 80 per cent of the length of the piece as above described; not to exceed 20 per cent of number of pieces may have this defect.

(d) In event that pieces have two faces as wide as above described and two faces narrower, the proportion of the amount of wane is admissible.

(e) Pieces 1 inch to 5 inches thick, not exceeding 8 inches wide, are governed by defect specifications above mentioned, with the exception that they shall not contain wane, and not to exceed 20 per cent of pieces 2 inches and thicker may show sound heart on one face; pieces under 2 inches thick must be free of heart. Pieces 8 inches and wider may contain wane as per paragraphs b and d.

(f) Rough sizes of structural timber shall not vary more than ¼ inch scant of specified size. Dressed sizes may be ½ inch scant after dressing.

V.—(B) Locomotive Timber Oak. Passenger Car Dimension Oak. Refrigerator Car Dimension Oak.

Thickness cut to order, widths cut to order, lengths cut to order. Unless otherwise noted, must be cut from white oak. This stock, wherever practical, should be cut outside the heart and must be free of heart shake in pieces under 6 by 6 square. No attempt should be made to box the heart in pieces smaller than 5 by 7, unless heart is very small and tight. When heart is well boxed it must be firm and tight, and the center of the heart must not be nearer than 2 inches from any face. Must be sawed full to sizes with square edges, and cut from sound timber and free from wormholes, with the exception of a few small pin wormholes well scattered, and an occasional spot worm. None of these defects, however, to affect the serviceability of the piece for the purpose intended. Must be free from split, rot or dote, large, loose, rotten or unsound knots, or, in other words, free of all defects affecting the strength and durability of the piece. Sound standard knots well scattered not considered a defect.

V.— (C) Freight Car Timber.

Freight car dimensions, including all cars other than refrigerator and passenger cars. Sizes cut to order. Unless otherwise ordered, must be sawed from good merchantable white or red oak timber. This stock must be free of rot, shakes and splits, large, loose, rotten or unsound knots, any of which will materially impair the strength and durability of the piece for the purpose intended. This stock is intended to work full size and length without waste for side posts, braces and end sills, end plates, drafting timbers, cross ties, etc., used in the construction of ordinary freight or stock cars. On pieces 3 by 4 inches or equivalent girth measurement and larger (nothing under 2 inches thick), heart check showing on one corner, admitted on twenty per cent of the pieces in each car shipment. Well-boxed, sound hearts admitted in this material in pieces 5 by 6 and larger.

On pieces 3 by 4 to 6 by 6, inclusive, or equivalent girth measurement and larger (nothing under 2 inches thick), in absence of heart defects, wane on one corner, ¾ inch side measurement, admitted on not to exceed twenty per cent of the number of pieces in each car shipment.

Pieces over 6 by 6 square may contain 1 inch wane, side measurement, on one corner, with other conditions same as 3 by 4 to 6 by 6 sizes.

CLASSIFICATION AND GRADING RULES FOR DOUGLAS FIR CAR AND LOCOMOTIVE MATERIAL.

1. The term "Douglas Fir" will cover the timber known likewise as Yellow, Red, Western, Washington, Oregon or Puget Sound Fir or Pine, Norwest and West Coast Fir.

2. *Douglas Fir Lumber* shall be graded and classified according to the following rules and specifications as to quality, and dressed stock shall conform to the subjoined table of standard sizes, *except where otherwise expressly stipulated between buyer and seller.*

3. Recognized defects in Douglas Fir are knots, knotholes, splits, checks, wane, rot, rotten streaks, wormholes, dog or picaroon holes, pitch seams, shake, pitch pockets, chipped grain, torn grain, loose grain, solid pitch, stained heart, sap stain and imperfect manufacture.

KNOTS.

4. Knots shall be classified as pin, small, standard and large, as to size; round and spike, as to form, and tight, loose and rotten, as to quality.

5. A pin knot is tight and not over ½ inch in diameter.

6. A small knot is tight and not over ¾ inch in diameter.

7. A standard knot is tight and not over 1½ inches in diameter.

8. A large knot is tight and any size over 1½ inches in diameter.

9. A round knot is oval or circular in form.

10. A spike knot is one sawn in a lengthwise direction.

The mean or average diameter of knots shall be considered in applying and construing these rules.

11. A tight knot or sound knot is one solid across its face, is as hard as the wood it is in, and is so fixed by growth or position that it will retain its place in the piece.

12. A loose knot is one not held firmly in place by growth or position.

13. A rotten knot is one not as hard as the wood it is in.

(See Exhibit D — Douglas Fir.)

EXHIBIT D — DOUGLAS FIR.

FIG. 1.— STANDARD KNOT.

FIG. 3.— SMALL SPIKE KNOT

FIG. 4.—LARGE KNOT.

FIG. 5.—SMALL KNOT.

Fig. 6.— Loose Knot.

Fig. 7.— Rotten Knot.

Fig. 8.— Pith Knot.

Fig. 9.— Pin Knot.

FIG. 10.— CLUSTER OF KNOTS.

PITCH.

14. Pitch pockets are openings between the grain of the wood, containing more or less pitch and surrounded by sound grain wood; they shall be classified as small, standard and large pitch pockets.

15. A small pitch pocket is one not over $\frac{1}{8}$ of an inch wide.

16. A standard pitch pocket is one not over $\frac{3}{8}$ of an inch wide, or 3 inches in length.

17. A large pitch pocket is one over $\frac{3}{8}$ of an inch wide or over 3 inches in length.

18. A pitch shake or seam is a clearly defined opening between the grain of the wood and may be either filled with granulated pitch or not, but in either case is considered a defect in any of the grades hereinafter described

19. A pitch streak is a well-defined accumulation of pitch at one point in the piece, and when not sufficient to develop a well-defined streak, or where fiber between grains is not saturated with pitch it shall not be considered a defect.

20. A small pitch streak shall be equivalent to not over one-twelfth the width and one-sixth the length of the piece it is in.

21. A standard pitch streak shall be equivalent to not over one-sixth the width and one-third of the length of the piece it is in.

Fig. 1.— Solid Pitch.

Fig. 2.— Large Open Pitch Pocket.

FIG. 3.—SMALL CLOSED PITCH POCKET.

Fig. 4.—Small Pitch Streak.

WANE.

22. Wane is bark, or the lack of wood, from any cause on edge.

SAP.

23. Bright sap shall not be considered a defect in any of the grades provided for and described in these rules, except where stipulated.

24. Sap stain shall not be considered a defect, except as provided herein.

25. Discoloration of the heart of the wood, or stained heart, must not be confounded with rot or rotten streaks. The presence of rot is indicated by decided softness of the wood where it is discolored or by small white spots resembling pin wormholes.

MISCELLANEOUS.

26. Defects in rough stock caused by improper manufacture and drying will reduce grade, unless they can be removed in dressing such stock to standard sizes.

27. All stock, except car sills and framing, shall be inspected on the face side to determine the grade. Stock surfaced one side, the dressed surface shall be considered the face side. Stock rough or dressed two sides, the best side shall be considered the face, but the reverse side of all such stock shall not be more than one grade lower.

28. Chipped grain consists in a part of the surface being chipped or broken out in small particles below the line of the cut, and as usually found, should not be classed as torn grain, and shall be considered a defect only when it unfits the piece for use intended.

29. Torn grain consists of a part of the wood being torn out in dressing. It occurs around knots and curly places, and is of four distinct characters — slight, medium, heavy and deep.

30. Slight torn grain shall not exceed 1-32 of an inch in depth; medium 1-16 of an inch, and heavy ⅛ of an inch. Any torn grain heavier than ⅛ of an inch shall be termed deep.

31. Loosened grain consists in a point of one grain being torn loose from the next grain. It occurs on the heart side of the piece, and is a serious defect, especially in flooring.

32. The grade of all regular stock shall be determined by the number, character and position of the defects visible in any piece. The enumerated defects herein described admissible in any grade are intended to be descriptive of the *coarsest* piece *such grades may contain*, but the average quality of the grade shall be midway between the highest and lowest pieces allowed in the grade.

33. Lumber and timber sawed for specific purposes must be inspected with a view to its adaptability for the use intended.

34. *All dressed stock shall be measured strip count, viz.: Full size of rough material necessarily used in its manufacture.*

35. Equivalent means equal, and in construing and applying these rules, the defects allowed, whether specified or not, are understood to be equivalent in damaging effect to those mentioned applying to stock under consideration.

36. Lumber must be accepted on grade in the form in which it was shipped. Any subsequent change in manufacture or millwork will prohibit an inspection for the adjustment of claims, except with the consent of all parties interested.

37. The foregoing general observations shall apply to and govern the application of the following rules:

The rules referred to under Sections 38, 39 and 40 govern 4-inch or 6-inch strips, and are intended to cover strips used for car siding, car roofing and car lining.

The term "Edge Grain" is here used an synonymous with vertical grain, rift-sawn, or quarter-sawed. The term "Flat Grain" is synonymous with slash grain or plain sawed.

No. 2 Clear and Better Edge Grain.

38. Material of this grade shall be well manufactured, with angle of grain not less than forty-five degrees. This stock shall be kiln-dried and practically free from all defects, but will admit of bright sap on the face; not exceeding three small close pitch pockets not over 2 inches long, one pin knot, slight roughness in dressing, but not a serious combination of these defects.

No. 2 Clear and Better Flat Grain.

39. Material of this grade shall be well manufactured. The stock shall be kiln-dried and practically free from all defects, but will admit of bright sap on the face; not exceeding three small close pitch pockets not over 2 inches long, one pin knot, slight roughness in dressing, but not a serious combination of these defects.

No. 3 Clear.

40. Material of this grade shall be sound common lumber and will admit of roughness in dressing, bright sap, and also may contain five pin, three small and one standard knot and five pitch pockets in any continuous 5 feet of length of the piece; or any combination of tight knots or pitch pockets equivalent to those mentioned above. This grade particularly refers to stock used for inside lining of freight cars.

Standard Car Decking or Flooring.

41. Material of this grade shall be well manufactured from sound live timber and shall be free from splits, shakes, rot, bark or waney edges, and unsound knots, or pitch pockets, pitch seams or large knots which would weaken the piece for the use intended. This grade will admit of sound knots not to exceed one-third width of the piece, provided they are not in clusters, and sap.

Common Car Sills and Framing.

42. Material of this grade shall be well manufactured from sound live timber, sawed full size to sizes ordered and free from rot, unsound knots, cross grain, bark or waney edges or shakes, but will admit of sap and any number of sound knots, provided they are not in clusters, and do not exceed one-third width of piece; pitch pockets or pitch seams that would not weaken the piece for the purpose intended.

43. *Sizes* up to 6 inches in width shall measure full when green, and not more than 1/8 inch scant when dry or part dry. Sizes 6 to 12 inches in width shall measure full when green and not more than 1/4 inch scant when dry or part dry. Sizes 12 to 16 inches in width shall measure full when green and not more than 3/8 inch scant when dry or part dry. Unless otherwise specified, 1/4 inch shall be allowed for each side which is to be dressed. In pieces 3 by 6 inches and under when ordered in lengths exceeding 30 feet, sound knots shall not exceed one-quarter the width of the face through which they project, and the grain shall not cross sufficiently to impair the strength.

44. Standard Lengths.

CAR SIDING — 8, 9, 10 and 12 feet or multiples.

CAR ROOFING — 5 feet or multiples.

CAR LINING — 8, 9, 10, 12, 14, 16, 18 and 20 feet or multiples.

CAR DECKING — 9 and 10 feet or multiples.

All orders shall be shipped in standard lengths, unless otherwise specified, but no lengths of either car siding, lining or roofing shall be shipped, except in the lengths specified or multiples thereof. Those who do not desire stock shipped in multiple lengths should so specify.

CLASSIFICATION AND GRADING RULES FOR CYPRESS CAR MATERIAL.

1. *Cypress* to cover Red, Gulf, Yellow and East Coast Cypress, also known as Bald Cypress.

2. *Cypress Lumber* shall be graded and classified according to the following rules and specifications as to quality, and dressed stock shall conform to the subjoined table of standard sizes, ***except where otherwise expressly stipulated between buyer and seller.***

3. Recognized defects in Cypress are knots, knotholes, sap, wormholes, shake, season checks, splits and wane.

KNOTS.

4. Knots shall be classified as standard and small, as to size, and sound or rotten, as to quality.

5. A standard knot is sound and not to exceed 1 1/4 inches in diameter

6. A small knot is one not exceeding 3/4 inch in diameter.

7. A sound knot is one solid across its face, is as hard as the wood it is in.

8. A rotten knot is one not as hard as the wood it is in.

EXHIBIT F—CYPRESS.

FIG. 1.—STANDARD SOUND KNOT.

FIG. 2.—SMALL SOUND KNOT.

FIG. 3.—TWO SMALL SOUND KNOTS EQUAL TO ONE STANDARD KNOT.

FIG. 4.—ROTTEN KNOT

SAP.

9. Stained sap or bright sap shall not be considered a defect in the material specified in these rules.

SEASON CHECKS.

10. Ordinary season checks are such as occur in lumber properly covered on yard or season checks of equal size in kiln-dried lumber.

WANE.

11. Wane is bark or lack of wood from any cause on edge.

MISCELLANEOUS.

12. The grade of all regular stock shall be determined by the number, character and position of the defects visible in any piece. The enumerated defects herein described admissible in any grade are intended to be descriptive of the *coarsest* pieces *such grade may contain*, but the average quality of the grade shall be better than the coarsest pieces allowed in the grade.

13. Lumber sawed for specific purposes must be inspected with a view to its adaptability for the use intended.

14. *All dressed stock shall be measured strip count, viz.: Full size of rough material necessarily used in its manufacture.*

15. Lumber must be accepted on grade in the form in which it was shipped. Any subsequent change in manufacture or millwork will prohibit an inspection for the adjustment of claims, except with the consent of all parties interested.

16. The foregoing general observations shall apply to and govern the application of the following rule. The rule referred to in the following section is intended to govern 4-inch or 6-inch strips and to cover strips used for car siding, car roofing and car lining.

CAR ROOFING AND SIDING.

"C and Better" Grade.—This grade will admit sound knots, stained sap, pin worm holes, very slight shake and other defects, but none that will prevent the use of each piece in its full width and length for car roofing and car siding; may be random or specified lengths and may be worked to pattern specified and graded from pattern side or S2S and C. M. and graded from the better side.

CAR LINING.

Shall be specified widths and 8 to 20 inches in length. Will admit tight knots, stained sap, pin wormholes, slight shake and other defects, but none that will prevent the use of each piece in its full width and length for car-lining purposes.

RECOMMENDATIONS.

At the convention in 1872 the following recommendations were adopted:

"In the matter of cost of keeping up the repairs of engines engaged in switching service exclusively, that an allowance of six miles per hour for the time that such engines are in actual use be allowed:

"That for engines running local freight trains an allowance of six per cent to the train mileage be added for switching:

"That where engines run empty to exceed one-half mile between where the trains are taken or left and the roundhouse, such mileage should be computed, and that for engines running through freight or passenger trains no computation should be made for switching:

RESOLUTIONS.

Revised and modified at convention, 1903.

At the convention of 1886 the following resolutions prevailed:

Resolved, That this Association deprecates the giving of testimonials or recommendatory letters for publication, and enjoins all to restrict matters of this nature to letters of inquiry. (See page 26, report 1886.)

Resolved, That it is the sense of this convention that in practice it is unnecessary to bead flues in the front end. (See page 152, report 1886.)

At the convention of 1888 the following resolution prevailed:

Resolved, That it is the sense of the Master Mechanics' Association that the pilots of all engines should have steps placed on the front end for the safety and convenience of brakemen while coupling at the front ends. (See page 162, report 1888.)

At the convention of 1893 the following resolution prevailed:

Resolved, That while the Master Mechanics' Association regards the water glass as a convenience and an additional precaution against low water, we do not regard it as an absolute necessity to the safe running of locomotives. (See page 161, report 1893.)

At the convention of 1896 the following resolutions prevailed:

Resolved, That it is the sense of this meeting that the radial stay boiler is as safe as the crown bar boiler, and that the former is easier to keep clean and more economical in repairs. (See page 280, report 1896.)

Resolved, That it is the sense of this Association that the statement of the performance of locomotives should be made on the basis of train load,

in lieu of train miles or loaded car miles, as is the prevailing practice at present. (See page 333, report 1896.)

At the convention of 1899 the following resolutions prevailed:

Resolved, That it is the sense of this convention that the time has not arrived when we can abandon instructions to those who use the air brakes, but that the time has arrived when we should perhaps take more care to instruct those who repair the brakes and keep them in order. (See page 71, report 1899.)

Resolved, That it is the sense of the American Railway Master Mechanics' Association that the use of fusible plugs in the crown sheets of locomotive fire boxes is not conducive to the prevention of the overheating of the crown sheet. (See page 153, 1899 report.)

Resolved, That it is the sense of this Association that the ton-mile basis for motive power statistics is the most practical, and encourages economical methods of operating; and that it is desirable that the heads of motive power departments urge its adoption on their managements. (See page 173, report 1899.)

Resolved, That it is the sense of this Association that it is not advisable to use bars in exhaust nozzles. (See page 277, report 1899.)

At the convention of 1901 the following resolutions prevailed:

Resolved, That it is the sense of this Association that a strict comparison of motive power statistics, one road with another, will not secure the best results, but that such comparisons should be made with the records of the same division for preceding periods of time. (See page 79, report 1901.) (See modification, page 70, 1902 report.)

Resolved, That it is the sense of this Association that the ton-mileage of the locomotive is a just credit to the motive power department for statistical purposes. (See page 83, report 1901.) (See modification, page 77, 1902 report.)

Resolved, That it is the sense of this Association that it is necessary that the side rods should be on engines traveling from the works to the railroad they are built for. (See page 99, report 1901.)

At the convention of 1902 the following resolutions prevailed:

"*Resolved,* That it is the sense of this Association that conclusions based on a comparison of the statistics of one railroad with another may easily prove incorrect, should be given less weight than they usually are, are just only when the accompanying conditions are fairly well known and their influence can be determined with some degree of accuracy; that a comparison of the statistics of a division or a system with those of the same territory for a previous corresponding period very largely eliminates these uncertainties and makes conclusions based on such a comparison much more reliable."

"*Resolved,* That it is the sense of this Association that the ton-mile-

age of the locomotive and caboose is a just credit to the motive power department for statistical purposes."

"*Resolved,* That the ton-mile is the best practical basis now available for motive power and operating statistics by which to judge the efficiency of locomotive and train service.

"*Resolved,* That actual tonnage should be used in computing ton-mile statistics for comparison with those of other roads, but for comparison with the previous records of the same system or division the use of adjusted tonnage is advisable.

"*Resolved,* That the statistics of passenger, freight, work train and switching services should be on the ton-mile basis, each service in a separate group, and passenger and freight service to be each further grouped under Through and Local.

"*Resolved,* That the statistics of branch lines and main lines should be kept separately.

"*Resolved,* That the credit of ton-mileage for locomotives in switching service should be proportional to their tractive power.

"*Resolved,* That the ton-mileage of trains using more than one locomotive should be divided among the locomotives attached to these trains in proportion to their tractive power and for the distance over which the helping locomotives are used.

"*Resolved,* That the tonnage of the locomotive should be its weight in working order, plus the light weight of the tender and half its capacity of coal and water."

At the convention of 1906 the following motion was adopted:

That twenty-four hours be adopted as the limit distinguishing between engines in service and those under repairs, and that $100 be adopted as the limit distinguishing between running and shop repairs.

Obituary.

ALEXANDER STEWART.

Alexander Stewart, late General Superintendent Motive Power and Equipment of the Southern Railway, died in Paris, France, June 28, 1914, while en route to Bad Nauheim, Germany, where it was hoped he would be restored to health after a year's illness.

Mr. Stewart was born at Fort Wayne, Indiana, February 22, 1868, and entered railroad service July 5, 1881, as Machinist Apprentice. At the completion of his apprenticeship he occupied positions as machinist, roundhouse foreman and District foreman in the service of the Union Pacific Railroad, until his appointment as Master Mechanic of that company at Cheyenne, Wyoming.

In February, 1903, he was appointed Master Mechanic of the Southern Railway at Knoxville, Tennessee, and in June of that year was appointed General Master Mechanic of what was then the Western District of the company. On April 1, 1904, he was appointed Mechanical Superintendent of the system, the title of the office later being changed to General Superintendent Motive Power and Equipment, and he occupied the position until his death. He was a member of the Master Mechanics' and Master Car Builders' Associations, having served on various committees of each and was elected President of the latter at the convention of 1911.

He was possessed of high attributes of heart and mind, and through his death the railroad lost a most efficient officer and those who knew him best, a loyal friend.

JOSEPH HAINEN.

EDWIN B. GILBERT.

Edwin B. Gilbert, Special Agent of Motive Power Department of the Bessemer & Lake Erie Railroad, died September 4, 1914, at his home in Greenville, Pennsylvania, from heart failure.

Mr. Gilbert was born December 13, 1844, in Windsor, New York, and after serving his machinist apprenticeship with the Erie Railroad at Susquehanna, New York, he moved to Youngstown, Ohio, and for a number

of years was employed as a machinist by the Lloyd Booth Company. He also was connected with the Erie Railroad at Youngstown as a machinist and roundhouse foreman. In 1883 he was transferred to Galion, Ohio, as roundhouse foreman, later becoming engine dispatcher. In 1888 he entered the employ of the Pittsburgh, Shenango & Lake Erie Railroad, which later became the Bessemer & Lake Erie Railroad, filling the positions of Foreman, Master Mechanic and Superintendent of Motive Power. At the time of his death he was Special Agent of the Motive Power Department of the Bessemer & Lake Erie Railroad, which position he held since his retirement as Superintendent of Motive Power in 1910.

Mr. Gilbert was a soldier during the Civil War and was confined in both Andersonville and Libby prisons.

The death of Mr. Gilbert removed a prominent figure from the Bessemer & Lake Erie Railroad and the Master Car Builders' Association. His cheerful disposition won him friends by the score and he was held in high personal regard by both the management and the railroad employees.

G. M. Gray.

WILLIAM S. MORRIS.

William S. Morris was born at Chicago, Illinois, on March 4, 1857, and died at Fort Wayne, Indiana, on June 15, 1915. He received rather better than the ordinary education, having attended the Cook County Normal School until 1874, when he began learning the machinist trade in the shops of the Housatonic Railroad at Bridgeport, Connecticut. In 1878 he went with his uncle, Chauncey Morris, to the Wabash Railroad at Fort Wayne, and remained with that company as journeyman machinist, locomotive fireman and locomotive engineer until 1883, when he went to the Fort Wayne, Cincinnati & Louisville Railway as Master Mechanic, where he remained a little over a year. Then he went to the Missouri Pacific Railway as Master Mechanic, and in 1886 he returned to the Wabash Railroad as Master Mechanic and remained there until 1889, when he was appointed Superintendent Motive Power and Rolling Stock of the Chicago and West Michigan, Detroit, Lansing & Northern and Sagamore Valley & St. Louis Railways, which position he relinquished in 1893 to accept the position of Superintendent Motive Power of the Chesapeake & Ohio Railway. He held that position for nine years and then went to the Erie Railroad as Mechanical Superintendent, where he remained for three years and then resigned to take up general mechanical engineering work. He was also engaged in business at Fort Wayne for several years, doing special engineering work from time to time. In 1910 he returned to the

Chesapeake & Ohio Railway and served until 1912 as Special Agent and Efficiency Engineer. He was then engaged on special work for various railroads and financial interests.

Mr. Morris was an industrious student of mechanical engineering, more especially that related to railroad operations. He took a keen interest in such organizations as railroad clubs and railroad mechanical organizations. He joined the Railway Master Mechanics' Association in 1887, was elected Vice-President in 1897 and was President of the Association in 1900 and 1901. He was a hard working member of committees and contributed valuable information on various subjects. He was a delegate to the International Railway Congress held in Berne, Switzerland, in 1910.

Mr. Morris was a member of the Episcopal Church and a Christian gentleman in every sense of the word, a good citizen, active in all good works, and highly esteemed and respected by everybody wherever he was known.

ANGUS SINCLAIR.

JAMES P. McCUEN.

Born at Uniontown, Pennsylvania, on September 17, 1844.

Died at Cincinnati, Ohio, October 2, 1914, aged seventy years.

Entered a Pennsylvania regiment, attached to the Federal Army, at the age of sixteen, and served until the close of the war.

After leaving the army he took service on the Pennsylvania Railroad in 1864, as machinist helper, and served as such and as machinist apprentice and as fireman, and was later promoted to locomotive engineer, serving in the latter capacity on that road until 1870.

From 1870 to 1871, worked for the Missouri Pacific Ry. as engineer.

From 1872 to 1880, employed as engineer on the Louisville Short Line, running a passenger engine between Louisville and Cincinnati.

1881, served as Traveling Engineer on Monon Road between Louisville and Chicago.

Took service with the Cincinnati, New Orleans & Texas Pacific Ry. about February, 1882, being employed in the capacity of Road Foreman of Engines. He remained in this position less than a year, and then went to the Monon in a similar capacity, but only remained a few months, again taking service with the Cincinnati, New Orleans & Texas Pacific Ry. as Fuel Inspector.

He was next given the position, in 1886, as Master Mechanic of the Cincinnati, New Orleans & Texas Pacific Ry. Chattanooga shops, and in 1887, went from there to Monroe, Louisiana, as Master Mechanic for the Vicksburg, Shreveport & Pacific Ry., where he remained for several years.

He was appointed Master Mechanic of the Alabama Great Southern R. R., at Birmingham, about January 1, 1894, serving one year, and was then transferred to the Cincinnati, New Orleans & Texas Pacific Ry. at Ludlow, being appointed Master Mechanic, January 1, 1895, and served in this capacity until October 10, 1915, at which time he was appointed Superintendent Motive Power.

He retained the position of Superintendent Motive Power until his retirement from active service November 1, 1910, when he was given the title of General Inspector, which position he had at the time of his death.

W. H. DOOLEY.

CHARLES JOHN McMASTER.

Charles John McMaster, oldest of a family of three daughters and two sons, born to John Sylvester McMaster, Scotch American, and Elvira Phillips McMaster, English American, was born at Pownal, Bennington County, Vermont, July 24, 1841. His father being a founder followed the iron industry through Canaan Ct., Cheshire, Massachusetts, into New York State, leaving Pownal in 1845, arriving at Copake Iron Works, New York, in 1854, situated on the New York & Harlem Railroad, where he remained as founder until his death in 1876. His mother continued to live in the same place until the time of her death in 1893.

During the year 1854, Charles John became much interested about the foundry, and while yet attending district school, from which he obtained his education, he secured the position of errand boy, acting before and after school hours and during vacations, and followed along in this way until he worked into the position of caretaker of machinery under the Chief Engineer. This he followed until 1858 when he accepted a place in the shops of the New York & Harlem R. R. Co., then located at the corner of Thirty-second street and Fourth avenue, New York city. He remained there only a short time when the Chief Engineer under whom he had worked at the Copake Foundry died and he was given that position, which he filled until 1860, and then went back to the Harlem Railroad shops, working as machinist and as fireman on the road until 1863, when he returned to his former position as Chief Engineer at the Copake Furnaces. In 1864 he married Caroline Elizabeth Thompson of Old Chatham, New York, remaining at Copake until 1865, when he resigned to accept a position as locomotive engineer on the New York & Harlem R. R., where he remained until 1867 when he took service with the Long Island R. R. as engineer, remaining until 1869, then coming back to the Harlem Exten-

sion R. R., located at Chatham, New York, as engineer, then to the Bennington & Rutland R. R. as engineer, located at Bennington, Vermont, only two miles from where he was born. In 1885 he was made Master Mechanic of the Bennington & Rutland R. R. In 1895 he was made Superintendent of Motive Power and Way, same road. In 1902 he was made Master Car Builder for the Rutland Railroad System. In 1903 made General Foreman of Motive Power and Rolling Stock of the O. & L. C. Division of the Rutland Railroad. In 1914 he was made Chief Mechanical Inspector for the entire Rutland Railroad System, and on the 17th day of November died in his office at Rutland, Vermont, in his seventy-third year. His wife having died seven months before, and having lost one son and one daughter, he was survived by two sisters, three daughters and two sons, all members of a railroad family. His brother, who died in early life, was an engineer. His two sisters married railroad men. His two sons are engineers, and his three daughters, with one exception, married railroad men.

He was a life member of the B. & L. E. Div. 145, New York city. A life member of the F. & A. M., Lodge 586, Long Island City. A member of the New England Railroad Club, member of the Master Mechanics' and Master Car Builders' Associations, and having a broad acquaintance was often consulted in reference to men and ways and works in connection with the old days of the Harlem and other railroads about New York city.

Hugh Montgomery.

ELI A. MILLER.

Mr. Eli A. Miller, Superintendent of Motive Power of the New York, Chicago & St. Louis Railroad, with offices at Cleveland, Ohio, died in that city, April 17, 1915.

Mr. Miller was born May 4, 1847, in Washington county, Pennsylvania. He was educated in the public schools.

From 1863 to 1865 he served as a private in the Civil War. He entered railway service in 1865, since when he had been, consecutively to 1866, laborer and helper with the Cleveland & Pittsburg Railroad; 1866 to 1871, machinist apprentice and machinist on the Pittsburg, Cincinnati & St. Louis Railway, at Dennison, Ohio; 1871 to 1873, machinist for the Louisville & Nashville Railroad, at Bowling Green, Kentucky; 1873 to 1880, foreman of the Pittsburg, Cincinnati & St. Louis Railroad, at Dennison, Ohio; 1880 to 1882, roundhouse foreman of the same road at Columbus, Ohio; 1882 to May 1, 1905, Master Mechanic of the New York,

Chicago & St. Louis Railroad, at Conneaut, Ohio. On May 1, 1905, Mr. Miller was appointed Superintendent of Motive Power of that road, which position he held until his death, April 17, 1915.

Mr. Miller, while Master Mechanic at Conneaut, Ohio, during a period of twenty-three years, held many positions of trust and honor in the city, in addition to his railroad duties, among which may be mentioned Superintendent of the Congregational Sunday School for twenty-three years; member of the school board; director in the First National Bank. He was a Knight Templar and member of the Grand Army of the Republic. He joined the American Railway Master Mechanics' Association in 1899.

Mr. Miller was a man of the highest character and irreproachable habits. His kindly disposition and his sense of justice, coupled with a scrupulous regard for dealing fair with every one, gained him many friends who deeply lament his loss.

He was a true Christian gentleman "without fear and without reproach." His funeral services were conducted by the Knights Templars. The floral offerings and the large attendance of friends from all parts of the System, testified to his great popularity.

The remains were interred in the family plot at Conneaut, Ohio. His wife, son and a daughter survive him.

T. A. Lawes.

WILLIAM McINTOSH.

The greatest kindness that a member of any society can bestow upon the organization he belongs to is to attend the meetings and to take active interest in promoting the work it has been formed to carry out. Regarded from that standpoint William McIntosh was one of the most valuable members of the American Railway Master Mechanics' Association. He joined the Association in 1900, when he was Superintendent of Motive Power of the Central Railroad of New Jersey, and from the first displayed keen interest in the meetings and in the committee work. He was elected a vice-president in 1903 and four years later was made president.

William McIntosh inherited some characteristics of a dour Scottish Highland Clan that generally displays itself in persistence in carrying on the work the hand has formed to do. He was born in Franklin, Quebec, and entered railroad service in the employ of the Chicago, Milwaukee & St. Paul Ry. as a machinist apprentice and advanced on the same road to be fireman, then locomotive engineer. Later he went to the Chicago & North Western Ry. as locomotive engineer, from which he advanced to be shop

foreman and then Master Mechanic, remaining in the latter position until 1899, when he resigned to accept the position of Superintendent of Motive Power of the Central Railroad of New Jersey. That position he relinquished in 1909, owing to impaired health. Death closed his career on March 15, 1915. He was an unusually skilful mechanic and invented numerous improvements on railroad rolling stock. He was a member of several Scottish societies and was highly esteemed for his general and obliging disposition by all who enjoyed his acquaintance.

ANGUS SINCLAIR.

ALBONIUS B. ADAMS.

Albonius B. Adams was born on September 2, 1864, at Wilson, Minnesota, died at Silsbee, Texas, February 16, 1914. He received his education in the public schools at the former point and in a business college at Winona, Minnesota. He served his apprenticeship as machinist in the Phoenix Iron Works, Winona, Minnesota, and in 1889 was employed in the Chicago & North Western Railway shops as machinist.

He accepted his first official position as General Foreman at Tracey, Minnesota, on the same road, and was later promoted to Division Foreman at Huron, South Dakota, remaining in the position until July, 1906, at which time he left the service of the North Western Railway, to enter the service of the Gulf, Colorado & Santa Fe Railway at Temple, Texas, as Roundhouse Foreman, which position he held until November 17, 1910, when he was promoted to General Foreman of the Cleburne shops, on the same road, where he remained until August 15, 1913, at which time he was appointed Master Mechanic of the Beaumont Division of the Gulf, Colorado & Santa Fe Railway, with headquarters at Silsbee, Texas.

Mr. Adams was a man of excellent reputation, led a life of intense activity and was a very faithful and efficient officer, who possessed many friends among railway employees.

J. E. McQUILLEN.

BENJAMIN BAKEWELL CARGO.

Mr. Benjamin Bakewell Cargo was born in Pittsburgh, Pennsylvania, July 9, 1862, and died at Lorain, Ohio, December 24, 1914. At the age of six years his parents located in Johnstown, Pennsylvania, where he attended the public schools, later attending Pennsylvania State College.

After leaving college he entered the employ of the Cambria Iron Company in the capacity of Locomotive Fireman. He was later employed by the Pennsylvania Railroad Company in a similar capacity. Leaving the employ of the Pennsylvania Railroad Company in 1885, he re-entered the employ of the Cambria Iron Company at Johnstown, Pennsylvania, as a Locomotive Engineer, leaving this position in 1889 to enter the employ of the Johnson Company, where his ability was so marked that in 1895 he was chosen Master Mechanic for the Lake Terminal Railroad Company, at Lorain, Ohio. This position he held with unusual ability until the time of his death.

He became a member of the Railway Master Mechanics' Association in 1904. He was ever a valuable and cherished member of the Association. Active in civic affairs, he took a keen interest in anything that tended to the moral and material betterment of his home town, and was a very valuable member of the Lorain Chamber of Commerce. He was a genial companion, a ready wit, and his presence was always welcome in any gathering. Kind and considerate of others, he was loved by his friends and associates, and his memory will long be cherished by all who knew him. He was an active member of the Lorain Lodge, No. 1301, B. P. O. E., and also a member of the Cleveland Automobile Club.

GEORGE N. RILEY.

THOMAS E. ADAMS.

Thomas E. Adams was born May, 1851, and died August 25, 1914.

He began railroad service in August, 1865, as a fireman on the Illinois Central at Centralia, Illinois. After promotion to locomotive engineer he served the Illinois Midland, St. P. M. & A. B. Ry. and the Great Northern until February, 1893, when he was appointed Master Mechanic on the latter line.

In 1896 he was appointed Superintendent of the Dakota Division. In 1897 he became Master Mechanic of the Fergus Falls Division.

He entered the service of the St. Louis & South Western as General Master Mechanic in 1901, and was appointed Superintendent Motive Power in July, 1905, which position he held until his demise.

Mr. Adams was an energetic officer and always carried the full courage of his convictions. He was painstaking in his duties and always prepared to render assistance or give advice to his subordinates in whatever capacity.

He is survived by his widow, two brothers and two sisters.

P. T. DUNLOP.

COLUMBUS PHILLIPS.

Machinist, Engineer, General Foreman and Master Mechanic.

Mr. Phillips was a member of the American Railway Master Mechanics' Association since 1900. He was born in Guinetter county, Georgia, in the year 1857 and died May 29, 1915, at Meridian, Mississippi. After a public-school education he began an apprenticeship with the Atlanta Rolling Mill & Machinery Company. From there he entered railroad service as machinist in 1874 and served as a locomotive engineer from 1875 to 1876, returning to service in the shop of the Georgia Pacific at Atlanta, Georgia, serving as General Foreman, and from 1881 to 1887 as Assistant Master Mechanic of the same company at Birmingham, Alabama.

He was also Master Mechanic of the Tennessee Coal, Iron & Railway Company a short while, Roundhouse Foreman of the Alabama Great Southern at Birmingham, Alabama, in 1898, General Foreman N. O. & N. E. and A. & V. Ry. July, 1899, and Master Mechanic N. O. & N. E. and A. & V. Ry. August, 1899, with headquarters at Meridian, Mississippi, until the date of his death.

Mr. Phillips was a man of splendid qualities, ever loyal to his employers and friends. He was held in the highest esteem and affection by all who enjoyed his acquaintance, as well as by the many employees of the various companies with whom he served. He was kind and generous, and always ready to lend the helping hand. He was the father of ten children, eight of whom survive him, five sons and three daughters. Mrs. Phillips, his wife, passed away about three years ago.

The railroad fraternity, of which so much is expected, can ill afford to lose such a man as this. An acquaintance of thirty years with Mr. Phillips gave me a peculiarly pleasing insight into his worth as a citizen and friend.

C. F. GILES.

MOTT EMMONS SHERWOOD.

Mr. Mott Emmons Sherwood was born at Mt. Vernon, Mt. Vernon county, New York, November 26, 1868. He came with his parents to Jackson, Michigan, in 1874, and obtained his education in the Eastern Central High School and St. Clair Private School.

At the age of sixteen he entered the service of the Michigan Central Railroad as a wiper, later being advanced to caller. After nearly a year of railroad work he left the service to learn the machinist trade, and later became stationary engineer for the Jackson Electric Light Company, subsequently serving in a similar capacity for the United States Baking Company.

He again entered the employ of the Michigan Central Railroad in 1890 as a machinist apprentice in the locomotive shop at Jackson, and from that time his advancement was rapid. On May 1, 1903, he was promoted to Foreman, in which capacity his ability attracted attention, and on February 1, 1905, was advanced to Assistant General Foreman. He was appointed General Foreman, September 1, 1907, and on August 1, 1910, became Division Master Mechanic, which position he capably filled until his death, June 4. 1915.

The circumstances surrounding his death were tragic, he being accidentally shot by a small nine-year-old boy practicing with a Winchester rifle.

Mr. Sherwood had a host of friends, who were ardent admirers of his strong character and irreproachable habits, and his loss is keenly felt by all who knew him.

W. H. Flynn.

WILBUR H. TRAVER.

Wilbur H. Traver was born in Michigan fifty-two years ago, but moved to Kirkland, Ohio, while still very young. The mechanical profession appealed to him, at first marine and later railroad work, and in this he made rapid progress, advancing to position of Master Mechanic in various shops of the Santa Fe. Mr. Traver had such a knack of making and holding friends that he drifted naturally into the selling end of the business and took a position in the sales department of the Rand Drill Company, with which he was connected for a period of fourteen years. In 1906, shortly after the Rand Drill Company and Ingersoll Sargeant Company consolidated their interests and formed the Ingersoll Rand Company, Mr. Traver cast his lot with the Chicago Pneumatic Tool Company, in whose service he remained until his death. He became a member of the American Railway Master Mechanics' Association in 1892, which membership he retained until his death. He belonged also to the St. Louis Railway Club, and the Western Railway Club of Chicago, the Elks' Lodge, No. 447, of Ishpeming, and Masonic Lodge, Jackson, Michigan, Royal Arch Chapter at Ravenswood, Illinois, Commandery of Knights

Templars at Denver, Colorado, and Shrine at Leavenworth, Kansas, also was a member of the Illinois Athletic Club and the Lake Superior Mining Institute.

Mr. Traver's thorough mechanical knowledge and experience, particularly in the field of compressed air machinery, served him well during the many years that he kept in touch with the mining industry, and few men have to their credit as long a list of sales and installations as had "Bill" Traver.

He left a wife and two sons, Delmar R., and Weir H. Funeral was held at his home, 4339 North Hermitage avenue, Ravenswood, Chicago, Saturday afternoon, April 17, and final interment was at his old home in Kirkland, Ohio, on the Sunday following.

THOMAS ALDCORN.

EBENEZER T. WHITE.

Ebenezer T. White was born October 16, 1858, at Frostburg, Maryland, and died September 25, 1913.

He entered service of the Baltimore & Ohio Railroad as machinist apprentice at Piedmont, West Virginia, shop, November 23, 1874, and continued in the service of the Baltimore & Ohio Railroad up to the time of his death, a period of nearly thirty-five years. During this time he was steadily advanced from the position of journeyman machinist to those of Gang Foreman at Piedmont in 1882; Roundhouse Foreman at Martinsburg, West Virginia, 1888; General Foreman at Baltimore, 1889; Master Mechanic of the Baltimore Division, 1890, and District Superintendent Motive Power of the Main Line District, with headquarters at Baltimore in 1899.

In addition to becoming very well known among railroad men, Mr. White was a prominent citizen in the various communities where he resided and was elected to the State Legislature in 1883 from Westernport, Maryland.

He left no immediate family, as he had never been married, but made his home with two nieces residing at 1815 West Baltimore street, Baltimore, Maryland. He was a member of the various Masonic Orders, including the Beauseant Commandery, Knights Templars, and was buried with Masonic rites September 28, 1913.

M. K. BARNUM.

CHARLES JOSEPH DRURY.

Charles J. Drury, Master Mechanic of the St. Louis & San Franciscc Railway at Sapulpa, Oklahoma, died in Springfield, Missouri, September 30, 1914, at the age of thirty-six, having succumbed to an attack of typhoid fever.

Mr. Drury was born in Chicago Junction, Ohio, September 17, 1878. He entered railroad service in July, 1895, as Machinist Apprentice with the Atchison, Topeka & Santa Fe. After completing his apprenticeship in July. 1899, he was employed as Machinist by the same road and later in the same capacity by the Southern Pacific, the Kansas City Southern, the El Paso & Southwestern, the Chicago, Rock Island & Pacific, and other roads. In July, 1906, he was appointed Roundhouse Foreman with the Santa Fe at La Junta, Colorado. He remained with this road until February, 1913, serving consecutively in the positions of Bonus Supervisor of the Western Grand Division; General Foreman at Albuquerque, New Mexico; Master Mechanic of the Oklahoma Division at Arkansas City, and Master Mechanic of the Plains Division at Amarillo, Texas. He then entered the service of the St. Louis & San Francisco Railway as General Foreman at Ft. Smith, Arkansas, and the following February was appointed Superintendent of Shops at Springfield, Missouri. Just prior to the illness of which he died, Mr. Drury was promoted to the position of Division Master Mechanic at Sapulpa, Oklahoma, on September 1.

Mr. Drury was a young man of unusual promise. He was possessed of a pleasing personality and an even temper, which, with his natural ability, gained him the confidence and good will of his superiors and subordinates alike. He is survived by his wife, four children, and his father, Mr. M. J. Drury of the Santa Fe.

M. H. Haig.

PHILIP P. MIRTZ.

Philip P. Mirtz was born November 20, 1883, at Scranton, Pennsylvania, and received a public-school education at the same place.

In 1899 he entered the service of the American Locomotive Company, at Scranton, where he completed a two years' course as draftsman apprentice.

He entered railroad service as Mechanical Draftsman for the Central Railroad of New Jersey in 1901, where he remained two years. In this same capacity he was also employed for two years by the New York,

Chicago & St. Louis Railroad, at Cleveland, and one year with the Erie Railroad, at Meadville, before taking service with the Lake Shore & Michigan Southern Railway in 1906. One year later he was appointed Chief Draftsman at the Collinwood shop and was afterward transferred in the same position to Elkhart shop where the superiority of his work was recognized by his promotion to Assistant Engineer of Motive Power at the general office in Cleveland.

In 1912 Mr. Mirtz was made Mechanical Engineer of the Lake Shore, and on its consolidation with the New York Central & Hudson River Railroad was transferred to New York in the capacity of Assistant Engineer under direction of the Chief Mechanical Engineer.

Considering Mr. Mirtz's early opportunities for an education his rise was a very rapid one, having attained the position which he held at the time of his death at the age of thirty-one years.

Mr. Mirtz died suddenly at his home in New York on May 11, 1915, and was buried at Scranton, Pennsylvania, the place of his birth. He is survived by his widow and both his parents.

He became a member of the American Railway Master Mechanics' Association in 1912.

R. B. Kendig.

PAST PRESIDENTS.

H. M. Britton	1868 to 1876.	Deceased.
N. E. Chapman	1876 " 1880.	Deceased.
J. N. Lauder	1880 " 1882.	Deceased.
Reuben Wells	1882 " 1884.	
John H. Flynn	1884 " 1885.	Deceased.
J. Davis Barnett	1884 " 1885.	Acting President.
J. Davis Barnett	1885 " 1886.	
William Woodcock	1886 " 1887.	Deceased.
Jacob Johann	1886 " 1887.	Acting President.
J. H. Setchell	1887 " 1889.	
R. H. Briggs	1889 " 1890.	
John Mackenzie	1890 " 1892.	
John Hickey	1892 " 1894.	
W. Garstang	1894 " 1895.	
R. C. Blackall	1895 " 1896.	Deceased.
R. H. Soule	1896 " 1897.	
Pulaski Leeds	1897 " 1898.	Deceased.
Robert Quayle	1898 " 1899.	
J. H. McConnell	1899 " 1900.	
W. S. Morris	1900 " 1901.	
A. M. Waitt	1901 " 1902.	
G. W. West	1902 " 1903.	Deceased.
W. H. Lewis	1903 " 1904.	
P. H. Peck	1904 " 1905.	Deceased.
H. F. Ball	1905 " 1906.	
J. F. Deems	1906 " 1907.	
Wm. McIntosh	1907 " 1908.	
H. H. Vaughan	1908 " 1909.	
G. W. Wildin	1909 " 1910.	
C. E. Fuller	1910 " 1911.	
H. T. Bentley	1911 " 1912.	
D. F. Crawford	1912 " 1913.	
D. R. MacBain	1913 " 1914.	
F. F. Gaines	1914 " 1915.	

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SUMMARY OF ILLUSTRATIONS

NUMERALS INDICATE STANDARDS; LETTERS, RECOMMENDED PRACTICE.

SHEET.

18. U. S. standard screw threads, nuts and bolts.
    Dimensions for castle nuts.

19. Dimensions for standard pipe unions.

20. Wheel-circumference measure for cast-iron wheels.

A. Terms and gaging points for wheels and track.
   Guard-rail and frog-wing gage.
   Wheel-mounting and check gage.
   Limit gage for remounting cast-iron wheels.

B. Minimum thickness for steel tires.
   Rotundity and plane gages for solid steel engine and truck wheels.
   Wheel-circumference measure for steel and steel-tired wheels.

C. Gage for measuring steel wheels to restore contour.

D. Branding of solid steel wheels and details of letters and figures.

E. 33-in. cast-iron wheels for cars of maximum gross weight not to exceed 95,000 lb.

F. 33-in. cast-iron wheels for cars of maximum gross weight not to exceed 132,000 lb.

G. 33-in. cast-iron wheels for cars of maximum gross weight not to exceed 161,000 lb.

H. 33-in. solid steel wheels for tender-truck service for 4¼ by 8, 5 by 9, 5½ by 10 and 6 by 11 in. axles.

I. 36-in. solid steel wheels for tender-truck service for 4¼ by 8, 5 by 9, 5½ by 10 and 6 by 11 in. axles.

J. 38-in. solid steel wheels for tender-truck service for 4¼ by 8, 5 by 9, 5½ by 10 and 6 by 11 in. axles.

K. 30, 33 and 36 in. solid steel wheels for engine-truck service for 4¼ by 8, 5 by 9, 5½ by 10 and 6 by 11 in. axles.

A. R. M. M.—1.

Standard Axles.

A. R. M. M.—2.

Standard Journal Box.
For Journals 3¾ by 7 inches.

A. R. M. M.—3.

Standard Journal Box and Contained Parts.
For Journal 3¾ by 7 inches.

A. R. M. M.—4.

Standard Bearing, Wedge and Lid.
For Journal 3¾ by 7 inches.

A. R. M. M.—5.

Standard Journal Box.
For Journal $4\frac{1}{4}$ by 8 inches.

A. R. M. M.—6.

Standard Journal Box and Contained Parts.
For Journal $4\frac{1}{4}$ by 8 inches.

A. R. M. M.—7.

Standard Bearing, Wedge and Lid.
For Journal $4\frac{1}{4}$ by 8 inches.

A. R. M. M.—6.

Standard Journal Box.
For Journal 5 by 9 inches.

A. R. M. M.—9.

Standard Journal Box and Contained Parts.
For Journals 5 by 9 inches.

A. R. M. M.—10.

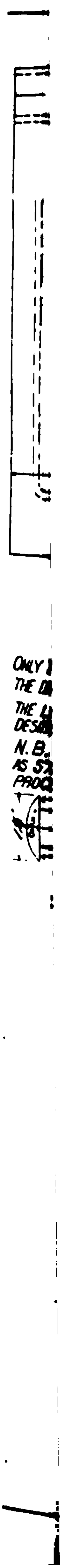
Standard Bearing, Wedge and Lid.
For Journal 5 by 9 inches.

A. R. M. M.—11.

Standard Journal Box.
For Journal 5½ by 10 inches.

A. R. M. M.—12.

Standard Journal Box and Contained Parts.
For Journal 5½ by 10 inches.



A. R. M. M.—13.

Standard Journal Bearing, Wedge and Lid.
For Journal 5½ by 10 inches.

A. R. M. M.—14.

Standard Journal Box and Contained Parts.
For Journal 6 by 11 inches.

A. R. M. M.—15.

Standard Journal Box.
For Journal 6 by 11 inches.

A. R. M. M.—16.

Standard Journal Bearing, Wedge and Lid.
For Journal 6 by 11 inches.

A. R. M. M.—17.

Standard Worn and Distorted Coupler Contour.

Standard Contour Line.

Standard Wheel Tread and Flange.

Standard Wheel Defect and Worn Coupler Limit Gauge.

Standard Gauging Points for Wheels.

Standard Flange Thickness Gauges for Cast-iron Wheels and Flange Thickness, Height and Throat Radius Gauges for Solid Steel and Steel-tired Wheels.

Standard Method of Gauging Worn Wheels.

Standard Sections of Steel Tires.

A. R. M. M.—18.

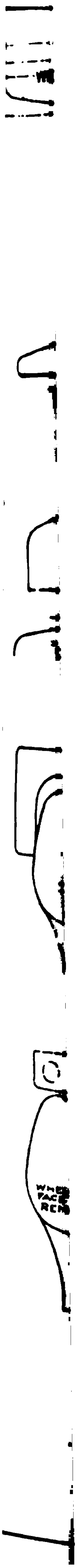
U. S. Standard Screw-threads, Nuts and Bolts.
Standard Dimensions for Castle Nuts.

A. R. M. M.—19.

Dimensions for Standard Pipe Unions.

A. R. M. M.—20.

Standard Wheel Circumference Measure for Cast-iron Wheels.



A. R. M. M.—A.

Recommended Practice
for
Terms and Gauging Points for Wheels and Track.
Guard Rail and Frog Wing Gauge.
Wheel Mounting and Check Gauge.
Limit Gauge for Remounting Cast-iron Wheels.

A. R. M. M.—B.

Recommended Practice
for
Minimum Thickness for Steel Tires.
Rotundity and Plane Gauges for Solid Steel Engine and Truck Wheels.
Tire Fastening for Steel-tired Wheels.
Wheel Circumference Measure for Steel and Steel-tired Wheels.

A. R. M. M.—C.

Recommended Practice
for
Gauge for Measuring Steel Wheels to Restore
Contour.

A. R. M. M.—D.

Recommended Practice
for
Branding of Solid Steel Wheels and Details
of Letters and Figures.

A. R. M. M.—E.

Recommended Practice
for
33-inch Cast-iron Wheels for Cars of Maximum Gross Weight Not to Exceed 95,000 lbs.

A. R. M. M.—F.

Recommended Practice
for
33-inch Cast-iron Wheels for Cars of Maximum Gross Weight Not to Exceed
132,000 lbs.

A. R. M. M.—G.

Recommended Practice
for
33-inch Cast-iron Wheels for Cars of Maximum
Gross Weight Not to Exceed 161,000 lbs.

A. R. M. M.—H.

Recommended Practice
for
33-inch Solid Steel Wheels for Tender Truck Service for $4\frac{1}{4}$ by 8, 5 by 9, $5\frac{1}{2}$ by 10 and 6 by 11 inch Axles.

A. R. M. M.—I.

Recommended Practice
for
36-inch Solid Steel Wheels for Tender Truck
Service for 4¼ by 8, 5 by 9, 5½ by 10 and
6 by 11 inch Axles.

A. R. M. M.—K.

Recommended Practice
for
30, 33 and 36 inch Solid Steel Wheels for Engine
Truck Service for 4¼ by 8, 5 by 9, 5½
by 10 and 6 by 11 inch Axles.